FINAL ENVIRONMENTAL ASSESSMENT

Limiting Mountain Lion Predation on Desert Bighorn Sheep on the Kofa National Wildlife Refuge

Lead Agency
U.S. Department of the Interior
Fish and Wildlife Service
Kofa National Wildlife Refuge

Cooperating Agencies
Arizona Game and Fish Department
USDA –APHIS Wildlife Services
Bureau of Land Management

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Table of Contents

ENVIRONMENTAL ASSESSMENT

1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

Introduction

The Kofa National Wildlife Refuge (Refuge) is a unit of the National Wildlife Refuge System (System) and is administered by the United States Fish and Wildlife Service (Service). The Refuge was established in 1939 by Executive Order 8039 which described the legal purpose being "for the conservation and development of natural wildlife resources, and for the protection of public grazing lands and natural forage resources." The Refuge is managed to fulfill the mission and goals of the System, as well as the specific purpose for which the Refuge was established. The mission of the System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.

The conservation of desert bighorn sheep (*Ovis canadensis mexicana*) was the driving factor in the establishment of the Refuge. In a letter to President Franklin D. Roosevelt on December 20, 1938, Lynn Lockhart, Chairman of the Democratic State Central Committee wrote: "During November and December 1937, it was proposed to set aside by Executive Order approximately 4,000,000 acres of land for the preservation of our bighorn mountain sheep…(Lockhart 1938)." Also, the Arizona Game Protective Association issued a proclamation at its annual convention in Safford, Arizona on October 1, 1938 that states, in part: "WHEREAS, our Gaillard Bighorn Mountain Sheep, located on the desert ranges of Pima County and Yuma County, are in danger of extermination, and WHEREAS, the Biological Survey [the precursor to the Service], the University of Arizona, and the Arizona State Game Department and other interested Agencies have made a study of the situation and have plans, which, if put into effect, will save this species of valuable wildlife, and WHEREAS, as a result of these studies and discussions, an Executive Order was drawn up during December 1937…which would set aside and establish two Bighorn Refuges to be administered by the Biological Survey, these refuges to be known as the Kofa Refuge, 672,500 acres in Yuma County, and the Cabeza Prieta Bighorn Refuge, approximately 881,440 acres…" Appropriately, much of the Refuge management has and continues to focus on the bighorn sheep population.

With the passage of the Arizona Desert Wilderness Act of 1990, most of the Refuge became designated wilderness. That act and the Wilderness Act of 1964 provide general legal guidance for wilderness portions of the Refuge. About 510,000 acres of the Refuge's 665,400 acres are designated wilderness. For wilderness areas within the System, the purposes of the Wilderness Act are considered to be "within and supplemental" to the purposes for the specific Refuge, i.e., the wilderness purposes are additional purposes for the Refuge and must be considered within the legal context of the applicable wilderness statutes. The preservation of wilderness values, which includes wildlife populations, is an important mandate that is considered in the management of the Refuge.

The Service, together with the Arizona Game and Fish Department (AGFD), conducts wildlife surveys, including desert bighorn sheep surveys. Recent bighorn sheep surveys have shown a decline in their numbers on the Refuge and nearby lands, including the New Water, Tank, Plomosa mountains (AGFD, unpubl. data). The Service has determined that limiting mountain lion *(Puma concolor)* predation on desert bighorn sheep could benefit desert bighorn sheep populations under certain circumstances. This environmental assessment (EA) analyzes various alternatives to actively manage mountain lion predation on desert bighorn sheep on the Refuge.

1.1 Purpose of the Proposed Action

The purpose of the proposed action is to provide the Service additional options for the management of the Kofa desert bighorn sheep population by allowing the Service to limit predation by mountain lions. The Service would coordinate and cooperate with its agents and partner agencies (for example, AGFD and others) to carry out actions identified in this document that are necessary to meet desert bighorn sheep management objectives on the Refuge. This would include the removal of "offending" mountain lions by either lethal means or through translocation. For purposes of this analysis, an offending mountain lion is defined as one that has killed two or more desert bighorn sheep within a six-month period.

1.2 Need for the Proposed Action

The National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd as amended) states, "The mission of the System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." Executive Order 8039 described the legal purpose to be, amongst other things, "for the conservation and development of natural wildlife resources." The bighorn sheep population on the Refuge is a natural wildlife resource in significant decline and in need of further management. The proposed action needs to be taken in order to meet the requirements of the National Wildlife Refuge System Improvement Act and Executive Order 8039.

Although mountain lions are also a natural wildlife resource, there is no indication that their populations are in decline; in fact, they may be increasing. As demonstrated by population modeling, mountain lion predation is likely additive to other sources of mortality and sufficient to prevent the Service from attaining bighorn sheep population objectives (See Section 4.6.5). Limited removal of individual mountain lions specifically identified as regularly preying on bighorn sheep, whether lethally or through translocation, could help the bighorn sheep population reach objective levels. The option of lethally removing offending mountains lions was identified in the *Investigative Report and Recommendations for the Kofa Bighorn Sheep Herd (Investigative Report)* in April 2007 (USFWS and AGFD 2007). The *Investigative Report* can be found on the internet at the following websites:
(www.fws.gov/southwest/refuges/arizona/kofa)
(www.azgfd.gov/w_c/bhsheep/index.shtml)

1.3 Location

The proposed action would be conducted by the Service within the boundaries of the Refuge (Figure 1). However, surrounding land and wildlife management agencies [including the Bureau of Land Management (BLM), U.S. Department of Agriculture – Animal and Plant Health Inspection Service – Wildlife Services (APHIS-WS), and the AGFD] are cooperating agencies in this process, and cooperative management practices could be facilitated at a landscape level. For example, the AGFD's predation management plan (the *Kofa Mountains Complex Predation Management Plan;* AGFD 2007) is very similar to the proposed action in this document.

The Refuge is geographically part of the Kofa Mountains Complex, which consists of the Plomosa, New Water, Kofa, Little Horn, Tank, and Castle Dome mountain ranges. These mountain ranges form a contiguous block of bighorn sheep habitat within which there is concern about declining bighorn sheep numbers.

1.4 Cooperating Agencies

Arizona Game and Fish Department. AGFD, acting under the Arizona Game and Fish Commission, and Arizona Revised Statutes Title 17, has trust responsibilities for the protection and management of all wildlife in the state. They have been a cooperator with the Service on the management of the wildlife on the Refuge since the Refuge was established. The Service and AGFD work jointly to improve wildlife habitat, to support and survey wildlife populations, participate together in research, translocation efforts, and outreach activities for the public.

Bureau of Land Management. The Bureau of Land Management (BLM), Yuma Field Office, manages approximately 1.1 million acres of public land in California and Arizona. The BLM manages public land adjacent to the Refuge, including the New Water Mountains Wilderness. The BLM and the Service jointly produced the *Kofa National Wildlife Refuge and Wilderness and New Water Mountains Wilderness Interagency Management Plan* (USDI 1997) which was completed in 1997. The public lands that are managed by BLM are set aside for a variety of uses. BLM participates in wildlife management primarily through the improvement of wildlife habitat. As a cooperating agency, BLM has provided input into the preparation of this document.

U.S. Department of Agriculture – Animal and Plant Health Inspection Service – Wildlife Services. The U.S. Department of Agriculture – Animal and Plant Health Inspection Service – Wildlife Services (APHIS-WS) has particular expertise in wildlife damage management. They have assisted the Service in the past with attempts to capture mountain lions to fit them with radio collars for tracking. They have also provided expertise to the Service concerning the writing of environmental documents.

1.5 Objectives and Scope

The objective and scope of this EA is to analyze possible approaches to managing mountain lion predation on desert bighorn sheep on the Refuge when the bighorn sheep population falls below the desired population level. The current objective for bighorn sheep management is to "maintain an optimal desert bighorn sheep population while providing for maximum viable species diversity" and the transplant goal is to "reestablish bighorn sheep throughout all suitable

historical habitats." The optimal desert bighorn sheep population objective is 800 animals based on 19 years of historical survey data (USDI 1997) and the need to maintain a population large enough to support transplants. Maintaining this size population is also dependent on a number of population limiting factors, including adequate habitat conditions. It is the intention of the Refuge to manage the bighorn sheep population to support regional and landscape level transplant programs. Predator management, which is not the elimination of predation altogether, is consistent with this objective.

Setting population objectives for one species at very high levels, seemingly at the expense of another species, warrants further discussion as it relates to Service policy. The Service's Biological Integrity, Diversity, and Environmental Health policy (601 FWS 3) states that each refuge will be managed to fulfill the refuge purpose as well as the Refuge System mission, and the Service will accomplish this by ensuring that the biological integrity, diversity, and environmental health of the refuge is maintained. Biological integrity, diversity, and environmental health can be described at various landscape scales from refuge to ecosystem, national, and international. Each landscape scale has a measure of these factors dependent on how the existing habitats, ecosystem processes, and wildlife populations have been altered in comparison to historic conditions. Individual refuges can contribute to biological integrity, diversity, and environmental health at larger landscape scales, especially when they support populations and habitats that have been lost at a larger scale. In pursuit of refuge purposes, individual refuges may at times compromise elements of biological integrity, diversity, and environmental health at the refuge scale in support of those components at a larger landscape scale. When evaluating the appropriate management direction for refuges, the Service considers the refuge's contribution to biological integrity, diversity, and environmental health at multiple landscape scales.

The bighorn sheep population objectives set for the Refuge are an example of management direction that was developed in support of landscape level conservation efforts. This is particularly true with regard to objectives meant to support transplant programs across a multi-state area. Service policy states that populations are managed for natural densities and levels of variation, however, on some refuges, including those with purposes tied to particular species, the Service can establish goals and objectives to maintain densities higher than those that would naturally occur in order to support conservation at multiple scales. Service policy also promotes, when and where practical, the support of reintroduction programs for native species in the context of surrounding landscapes.

The results of this EA will remain applicable until the Service determines that the need for action should be revisited or issues driving this EA change substantially. The need to intensively manage mountain lions will change as bighorn numbers increase and as data from ongoing research projects are analyzed, the results of which will guide future efforts. The Service is scheduled to begin the development of a Comprehensive Conservation Plan (CCP) no later than 2014. That planning process may ultimately revisit this issue, along with other issues and management programs for the Refuge.

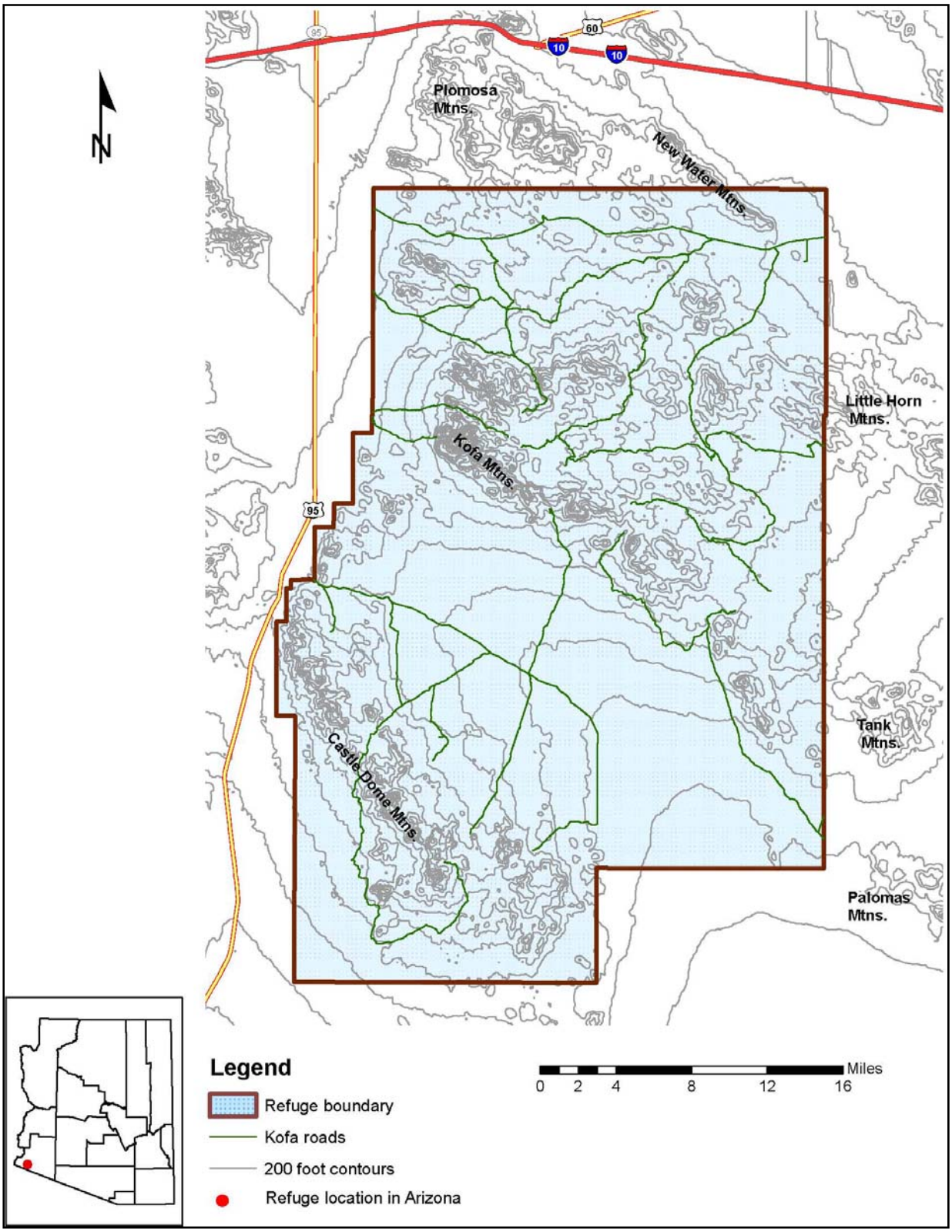

Figure 1. Location map of Kofa National Wildlife Refuge.

1.6 Relationship of this Environmental Assessment to Other Environmental Documents

Kofa National Wildlife Refuge and Wilderness and New Water Mountains Wilderness Interagency Management Plan, Environmental Assessment, and Decision Record (USDI 1997). This is the Refuge's comprehensive management plan which directs and authorizes management of the Kofa National Wildlife Refuge, including management objectives for bighorn sheep, other wildlife, wilderness, and recreation. Finalized in 1997, this document will be supplanted by the Refuge's CCP which will be developed beginning no later than 2014.

Investigative Report and Recommendations for the Kofa Bighorn Sheep Herd (USFWS and AGFD 1997). This document, prepared by AGFD and the Service in 2007, outlines management strategies for the Refuge bighorn sheep population.

Kofa Mountains Complex Predation Management Plan (AGFD 2007a). This document was prepared by the AGFD in 2007 to address predation on bighorn sheep within the Kofa Mountains Complex, including the Kofa, New Water, South Plomosa, Tank, Little Horn, and Castle Dome Mountains.

Arizona Comprehensive Wildlife Conservation Strategy (AGFD 2006). AGFD prepared a wildlife management strategy in 2006 which guides actions to be conducted in Arizona to conserve wildlife resources.

Minimum Requirements Decision Guide for Limiting Mountain Lion Predation on Desert Bighorn Sheep on Kofa National Wildlife Refuge (2009). This document evaluates the impacts of mountain lion capture, tracking, and removal on the wilderness resource (attached as Appendix E).

2.0 BACKGROUND AND RESOURCE ISSUES

2.1 Background

The regional importance of the Kofa desert bighorn sheep population is widely recognized, and it has been a source for translocations since 1957. From 1957 through 2006, 569 bighorn sheep were captured on the Refuge and released in new areas to supplement populations in Arizona, New Mexico, Colorado, and Texas. The Refuge bighorn sheep have provided vital population boosts and genetic variety to bighorn sheep herds throughout the southwest. The Refuge has supplied numerous desert bighorn sheep to New Mexico, and the population of desert bighorn there was recently downlisted from endangered to threatened. After the decline noted in 2006, the translocation program was suspended indefinitely until the population meets translocation guidelines set out in USDI 1997. The suspension includes a pending translocation of additional bighorn sheep to San Andres NWR in southern New Mexico, along with planned transplants in Arizona to the Mineral, Bighorn, and Santa Catalina Mountains among other locations. If the population objectives can be met, translocations can continue, which would provide benefits to bighorn populations over the entire southwestern region, while still maintaining a source population of bighorn sheep on the Refuge.

Desert bighorn sheep are the key species of importance on the Refuge, and the goal of many refuge visitors is to see and photograph bighorn sheep. The decline in the bighorn sheep population has made viewing the animals more difficult. In addition, hunting desert bighorn sheep on the Refuge is a lifelong goal for many individuals, and for those individuals who draw a bighorn sheep tag for the Refuge, the effort to locate trophy rams has become more difficult than in the past. Desert bighorn sheep tags are very limited; they are only issued for 10 to 15 percent of the Class 3 (6 to 8 year old animals) and Class 4 rams (8 years and older) estimated from the most recent surveys. For the December 2009 hunt, 6 desert bighorn sheep tags were approved for the Refuge.

The current method of systematically surveying the Refuge bighorn sheep population by helicopter triennially was initiated in 1992. The Kofa, New Water, Little Horn, Tank, and Castle Dome Mountains are divided into blocks using geographic features in order to standardize the areas flown and level of effort in each area. Bighorn sheep populations are estimated using the "Kofa Group Size Estimator" developed by Hervert et al. (1998). This estimator was developed from mark-resight rates using collared bighorn sheep, and corrects for the fact that observers are more likely to see large groups of bighorn sheep on surveys and less likely to see small groups or individuals. Surveys from 1987-1991 were based on the same block system as is used now, but a sample of 50% of the Refuge was surveyed annually and the estimate extrapolated to the whole. This tended to result in more variable estimates than complete surveys. From 1981-1987, complete aerial surveys were conducted but the current survey blocks had not been defined. Before 1980, population estimates were based on animals observed during foot and aerial lamb surveys and water hole counts. When the "Kofa Group Size Estimator" was developed, it was applied to all the raw data collected since 1981 to standardize the population estimates. This estimator generally resulted in smaller population estimates than those obtained using only an average sighting rate. Although data before 1992 may not be directly comparable to data obtained after 1992 because of minor differences in survey technique, the Service is confident that the population trend is valid. Population estimates for 1981-2009 are given in Figure 2.

Even though survey methods have changed since the early 1980s, limiting comparisons between years, systematic aerial surveys indicate that an approximate 50% decline in the Refuge population has occurred between the years 2000 and 2006. Surveys in 2007 (a population estimate of 460 animals), 2008 (an estimate of 436 animals), and 2009 (an estimate of 410 animals) suggest that the population of desert bighorn sheep remains at about half of the 20-year survey average (Figure 2). The estimate of 390 sheep from the 2006 survey was the first time since 1981 that the population estimate was below 600 bighorn and represents the sharpest decline recorded since aerial surveys were initiated.

2.2 Desert Bighorn Sheep Conservation Efforts

In addition to suspending translocations of bighorn sheep from the Refuge, the population decline noted in 2006 by resource management agencies motivated the Service and AGFD to implement several actions, outlined in the jointly-written *Investigative Report.* In order to better understand the reasons for the population decline, 45 ewes were captured and collared in 2007 and 2008. These ewes were tested for disease measured for body condition, and have been monitored regularly by the U.S. Geological Survey (USGS) – New Mexico Cooperative Research Unit, for information on habitat use, lamb production, and causes of mortality. The

Service and USGS are also collaborating on mountain lion diet and genetics research through the Arizona Cooperative Research Unit. Results from research efforts will be incorporated into planning for bighorn sheep and mountain lion management as they become available. Preliminary information from these research efforts indicates that predation by mountain lions is an important cause of desert bighorn sheep mortality on the Refuge. More information concerning the ongoing studies can be found in Section 4, Affected Environment.

As recommended in the *Investigative Report*, two permanent water redevelopments and one new temporary water source have been developed for bighorn sheep, and existing waters considered critical for bighorn sheep have been actively maintained through water hauling, when required. The Service and AGFD have also conducted aerial surveys every year since 2006, as opposed to the historical triennial schedule that has been followed since 1994. The impacts of disturbance from public use are unknown, but the Service intends to investigate this potential adverse effect when adequate staff and funding become available.

In addition, one of the strategies proposed in the *Investigative Report* is the removal of "offending" mountian lions from the Refuge. The report defines an "offending" moutain lion as one that kills two or more bighorn sheep within a six month period. The purpose of this EA is to provide the regulatory compliance and public participation required for evaluating the mountain lion management approach proposed in the *Investigative Report*, since it has not been addressed in previous Refuge decision documents.

2.3 Mountain Lion Predation

The impact of predation on bighorn sheep populations and the rationale for removing offending mountain lions for bighorn sheep management were discussed in the *Investigative Report.* An updated summary of the history behind this issue follows.

Mountain lions are one of ten big game species hunted in Arizona. The statewide population is estimated by the AGFD to be between 2,500 and 3,000 animals. About 300 mountain lions per year are harvested through hunting or killed because of livestock depredation. Mountain lions are more common in the mountainous regions of Arizona compared to the deserts.

Mountain lions have historically been suspected to be largely transient on the Refuge. There were no verified records of mountain lions on the Refuge until a U.S. Bureau of Sport Fisheries and Wildlife employee killed a male mountain lion near Squaw Tank in 1944 (Halloran and Blanchard 1945). There were no additional verified records between 1944 and 2001, despite two separate surveys conducted specifically for mountain lion sign in the 1980s and 1990s. Shaw et al. (1988) found no lion sign along nine routes on the refuge, nor any along the additional nine routes in nearby areas of the Lower Colorado River Valley subdivision of Sonoran Desertscrub vegetation . From 1995-1997, Germaine et al. (2000) conducted surveys for mountain lions in 18 mountain ranges and along the Colorado and Gila rivers in southwestern Arizona, including the Refuge. They found no evidence of lions on the Refuge and suggested that a distinct, self-sustaining mountain lion population did not exist in southwestern Arizona during the survey period.

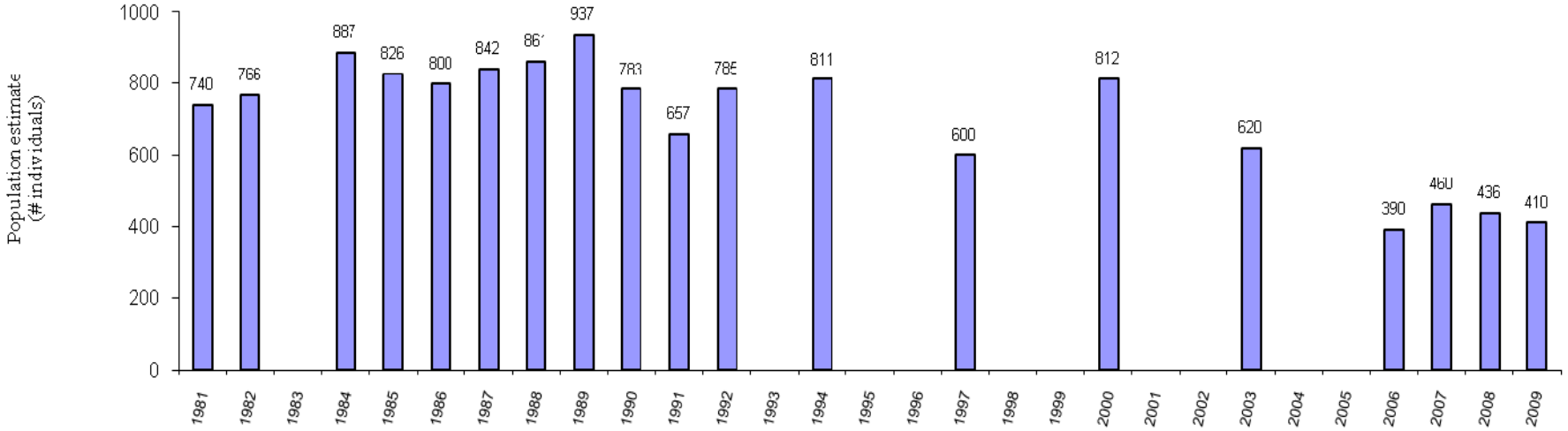

Figure 2. Refuge Bighorn Sheep Population Estimates, 1981-2009*

* 1983 is not included because although the summary number of sheep observed is known, the raw data sheets containing the data required to apply the Group Size Estimator to obtain a population estimate are missing. Data gaps after 1992 indicate years in which surveys were not conducted. See section 2.1 for a discussion of survey and estimation methods.

After a cached deer was found at Little White Tanks in the Castle Dome Mountains in 2001 and three mountain lions (believed to be a female lion and two kittens) were seen on an aerial survey in the Kofa Mountains in 2003, Refuge staff placed eight active infrared and two passive heat- and motion-sensing digital remote cameras at water holes in the Kofa Mountains beginning in December 2003. A single camera was placed at a water source in the Castle Dome Mountains in 2002 and additional cameras were added in the Castle Dome Mountains beginning in 2006. The Refuge currently maintains 13 remote cameras for wildlife monitoring.

Using photographs from these cameras in combination with surveys by biologists and experienced houndsmen knowledgeable about mountain lions, at least five lions were documented on the Refuge in 2006, including both the Kofa and Castle Dome mountain ranges (Smythe, 2008). The actual density of mountain lions on the Refuge and immediate surrounding area is unknown, but photographs of spotted juveniles or females with kittens have been obtained on the Refuge in successive years (2004, 2005, 2006, 2007, and 2009), suggesting a local breeding population. Collaring and scat sampling data from areas east of the refuge have identified two more mountain lions, a male that uses primarily the Gila Bend Mountains, and a female whose range is unknown but includes the eastern edge of the Tank Mountains. This suggests that the lions using the Refuge are not an isolated or unique population. More detail on genetics work is described in Section 4.5.5.

In 2007, the Service and AGFD collared three adult male mountain lions (designated KM01, KM02, and KM03) with satellite Global Positioning System (GPS) collars. In 2009, a fourth adult male mountain lion (KM04) was collared. The lions were found to kill and consume desert mule deer (*Odocoileus hemionus*), desert bighorn sheep, coyotes (*Canis latrans*), badgers (*Taxidea taxus*) and an undetermined fox (kit or gray).

Data on sheep predation from the four radio-collared mountain lions (KM01, KM02, KM03, and KM04) were used to estimate the impacts of mountain lions on the bighorn sheep herd. The number of bighorn sheep killed by these lions is summarized in Table 1. This data was used to complete the modeling described in section 4.6.5.

Table 1. Number of bighorn sheep killed by mountain lions collared on Kofa NWR.

Mountain Lion	Duration collared	# bighorn killed[a]	# ewes killed[b]	# bighorn killed in Kofa Mtns. Complex[c]	# ewes killed in Kofa Mtns. Complex[b]
KM01	3 months	5	3	5	3
KM02	2 months	1	1	0	0
KM03	5 months	6	1	6	1
KM04	6 months	16	4	11	3

[a]this includes all ram, ewe, and lamb kills made by collared lions, on or off the Refuge

[b]# of ewes killed does not include lambs for which sex could not be determined

[c] this includes all ram, ewe, and lamb kills by made by collared lions within the Kofa Mountains Complex

As of October 2009, nine out of the 12 documented mortalities of collared bighorn ewes were attributed to mountain lions. This is in contrast to previous studies of collared ewe mortalities between 1993 and 1996, when 17 mortalities were investigated and none were attributed to mountain lions. All of the desert bighorn sheep radio-collars in this earlier study transmitted only using VHF (none were satellite GPS collars as some are now) so the investigation of sheep mortalities sometimes took place weeks after the animal had died. Biologists described the 17 deaths as follows: three sheep drowned, three were unknown, but the skulls did show signs of chronic sinusitis, six appeared to be of natural causes with no sign of predation or chronic sinusitis, one fall, and four unknown with very little evidence left.

Previous investigations from other localities (see Section 5.2.2) indicate that mountain lion predation can limit bighorn sheep populations under some circumstances and that removing those mountain lions that regularly target bighorn sheep is the most effective way to reduce the impacts of predation. The Service recognizes that mountain lion predation is not the only factor limiting the population size of bighorn sheep on the Refuge. For example, if individuals cannot maintain adequate levels of physical condition, populations cannot be productive regardless of the status of other potential limiting factors. However, limiting mountain lion predation on bighorn sheep will have the most immediate positive consequences for the herd until other factors can be quantified and addressed.

2.4 Summary of Public Involvement Efforts

On April 23, 2008, the Service announced its intent to prepare an Environmental Assessment of alternatives for the management of mountain lions on the Refuge. A 30-day scoping period from April 24 to May 24, 2008 was established under that notice. The Service provided a news release and sent out 4,007 letters and emails to potential interested parties announcing the initial scoping period for development of a lion management EA. In response to requests from the public, the Service extended the public scoping period an additional 30 days, to June 23, 2008.

During the scoping period the Service received 122 response letters or emails with comments that were considered as part of this analysis. See Appendix B for a list of agencies, individuals, and organizations that provided scoping comments and a summary of the scoping comments.

A Notice of Availability of the Draft EA was published in the Federal Register on August 4, 2009 and was available for public review and comment for 60 days. Service representatives met with representatives of six environmental groups in Tucson, Arizona in an informational meeting on the afternoon of September 9, 2009. The purpose of this meeting was to answer questions prior to the preparation of comments. An informational public meeting was held in Yuma, Arizona on the evening of September 16, 2009 and 60 members of the public attended. During the comment period 221 letters, e-mails, and comment forms handed out at the public meeting were received. All comments were considered during the preparation of the Final EA with some additional issues raised. See Appendix C for a list of the agencies, organizations, and individuals that provided comments on the Draft EA and a summary of the comments and responses to those comments.

Copies of this EA are available upon request from Kofa National Wildlife Refuge, 9300 E. 28th St., Yuma, AZ 85365; 928-783-7861.

2.4.1 Issues and Concerns. The following issues and concerns were identified during the scoping period or during the comment period for the Draft EA. These issues are addressed below in Section 2.4.2, in Appendix C, or in the body of the document

Mountain lion populations – What impacts will the removal of mountain lions have on local and statewide mountain lion populations? What would the cumulative and direct impacts be from implementing the proposed action or other alternative? Should mountain lion hunting be allowed on the Refuge as a method of reducing their population? Are these mountain lions actually the rare Yuma puma (*Puma concolor browni*) subspecies, which should be protected, although McIvor *et al.* (1995) and Culver et al. (2000) presented evidence suggesting Yuma puma is not likely a subspecies? Should translocations be considered as the only option for removing mountain lions? Should translocations be eliminated as an option?

Bighorn sheep populations - What impact will the removal (or lack thereof) of mountain lions have on the local and statewide desert bighorn sheep populations? What would the cumulative and direct impacts be from implementing the proposed action or other alternative? Are mountain lions causing the drop in the sheep population estimates, or is there another cause, such as disease, drought, or malnutrition? Should hunting of desert bighorn sheep be suspended until sheep populations have increased? Will the number of bighorn sheep on the Refuge continue to affect the state and regional bighorn sheep transplant programs? If mountain lions kill only the sick and the weak bighorn sheep, could mountain lion predation be considered beneficial? Should the population goals for desert bighorn sheep on the Refuge be changed? Should Alternative C – Indiscriminate Mountain Lion Removal be implemented since this most closely approximates actions which reduced predation rates on desert bighorn sheep in New Mexico? What are the consequences of removing female lions and mountain lion kittens? Would the removal of some mountain lions cause a trophic cascade similar to what was observed in the Greater Yellowstone Ecosystem when wolves were introduced? Should desert bighorn sheep habitat be improved regionally to provide more resilience to mountain lion predation? Should captive breeding of desert bighorn sheep be considered as an option?

Impacts on non-target species – What impact will the removal (or lack thereof) of mountain lions have on other species not targeted, including desert mule deer?

Impacts on public recreation – Will there be impacts from alternatives to visual resources and visitor use of the Refuge?

Impacts to wilderness – Will there be impacts from alternatives to wilderness values on the Refuge or conflicts with wilderness management? Should management actions be curtailed or eliminated in wilderness and "nature be allowed to take its course?"

Humaneness – How humane are the respective alternative strategies? Because humaneness can be dependent on perspective (USDA 1997), how is humaneness perceived by the various interests?

Cumulative impacts – What are the impacts of the alternatives when considered with other relevant management actions on the Refuge and in nearby regions over time?

National Environmental Policy Act concerns – Were Native American tribes consulted? Should the 60-day Draft EA comment period have been extended to 90 days? Is the Purpose and Need legitimate and consistent with Service laws and policies? Was the Affected Environment adequately described? Are direct and indirect impacts completely discussed? Should an Environmental Impact Statement be prepared?

2.4.2 Issues Not Analyzed in Detail with Rationale

Impacts from water developments
The Service has developed numerous water sources for wildlife on the Refuge since its establishment in 1939. Currently, the Service maintains water at 23 critical sites (two springs, 15 modified natural rock pools, five man-made catchments, and one windmill) for bighorn sheep that were identified in the *Investigative Report*. There are an additional 11 windmills, 11 springs, 26 natural rock pools or manmade catchments, and 10 dams throughout the Refuge. Except for springs, wells, and critical waters, most of these water sources are ephemeral depending on rainfall. The extent to which these water developments may have influenced wildlife populations over the past 70 years is not known, although several recent studies have documented extensive wildlife use of waters in southwestern Arizona and on the Refuge (O'Brien et al. 2006, Lynn et al. 2006). Marshall et al. (2006) found no association between wildlife water developments and reduced forage availability in the Lower Colorado River Valley in California, and Bleich et al. (2006) concluded that the quality of water at man-made water sources in southeastern California desert environments does not constitute a wildlife health threat. Longshore et al. (2009) found that because of the drying of natural springs in Joshua Tree National Park, nearly half (47.4%) of the historical remaining critical summer bighorn sheep habitat was located around artificial water developments. The authors suggested that artificial water sources may be maintaining bighorn sheep populations in the face of historical habitat loss and raised concerns about whether bighorn sheep would persist on natural water sources alone if artificial sources were removed.

Data from the radio-collared mountain lions indicates that 31% of ungulate kills occurred within 1600 meters of a known permanent or semi-permanent water source, while 17% occurred within 800 meters. Only 11% of ungulate kills occurred within 100 meters of a water source (USFWS, unpubl. data).

Thus, it is known that the Refuge water sources are used extensively by a variety of wildlife species, including desert bighorn sheep and mountain lions. There is no indication that use of water by wildlife on the Refuge causes "overgrazing" near the water sources, nor has this been indicated in previous studies of wildlife waters (Marshal et al 2006). The data from the radio-collared mountain lions and previous studies (O'Brien et al. 2006) suggests that wildlife water sources do not constitute a "predator trap" where prey species are likely to be killed by a predator.

Impacts from climate change
Most climate prediction models indicate that the southwest will become hotter and possibly drier over the next few decades, but predictions for specific areas are unreliable. A study in California indicated that precipitation and elevation (used as a surrogate for temperature) are strongly

correlated with bighorn population persistence in models (Epps et al. 2004) and suggested that climate warming may have already affected desert bighorn distribution in California. If the southwest does become hotter and drier, the Refuge may become even more critical for the preservation of desert bighorn sheep herds since it includes areas of relatively high elevation (up to over 4,800 feet); these areas might become vital to bighorn sheep herds if lower elevation habitat becomes unsuitable. This issue is a serious concern because it could potentially impact Refuge habitat in the future. Thus, global warming will be addressed in the Service's future planning efforts for the Refuge. It currently has no noticeable impact on the current Kofa bighorn sheep population, since other bighorn sheep populations in southwestern Arizona have increased or been stable while the Refuge population has declined. Data from the Kofa Mine weather station during the period of record (1952-2008), indicate that the average temperature has remained constant, while the average rainfall (though highly variable from year to year) has trended upward slightly. This would suggest no obvious microclimatic change in the immediate past. These data are obtainable from the Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?az4702 and graphed in Section 4.1.

Increased temperatures, decreased rainfall, and drying of the Southwestern United States are some of the predicted consequences of human-induced climate change due to increased carbon dioxide and other trace gases in the atmosphere. Less water in an already arid region will affect the overall ecology of the Sonoran Desert. The relationship between the modern distribution of a plant species and climatic parameters provides the basis for estimating how future climatic changes may influence plant species distributions. The continued effect that global warming will have on bighorn sheep, from the plants they eat to the insects that pollinate those plants, potential increase of unpalatable invasive plant species, increased disease potential, and water availability, are not well understood nor specifically predictable. However, it is agreed that changing atmospheric circulation patterns and warmer, dryer air will increase aridity and affect plants that sheep and other large herbivores (deer) require for food. These factors, with the compounding effects of increased predation pressures, increase the jeopardy of a sustainable sheep population and substantiate the necessity of prudent wildlife management.

2.5 Development of Alternatives for the EA from the Identified Issues

This EA was prepared using guidelines of the National Environmental Policy Act of 1969 (NEPA). NEPA requires examination of the effects of proposed federal actions on the natural and human environment. In the following chapters, three alternatives for future management of mountain lion predation on the Refuge are described, along with the environmental consequences of each alternative in relation to the issues identified in this chapter. The alternatives, including the proposed action, were designed to cover an array of possible actions that could achieve the objective of increasing bighorn sheep numbers while meeting the purpose and mission of the Refuge and System.

3.0 DESCRIPTION OF THE ALTERNATIVES (INCLUDING PROPOSED ACTION)

A variety of alternatives were considered in the development of this EA.

The Service has identified the alternatives, developed through interagency planning and public scoping, that could meet the need for action and objectives identified in Chapter 1 and that represent viable scenarios for future management of the Refuge. The alternatives that will be considered are 1) the No Action Alternative which is to continue current management efforts, 2) the Proposed Action Alternative which involves limited removal of mountain lions, and 3) an Indiscriminate Removal of Mountain Lions Alternative.

3.1 Alternative A: No Action Alternative – Continue Current Management Efforts

Under the No Action Alternative, the Refuge would continue to be managed as it has been in the past. This is considered the environmental baseline, or *status quo*. Since bighorn sheep management and mountain lion predation management outside the Refuge have been conducted in Arizona for decades, the environmental baseline can be considered as including the effects of the current ongoing programs. The wildlife population baselines are those that are in place under the current condition of the human environment which means they incorporate and reflect the populations as they have been and are being affected by humans.

The Service currently has no Refuge-wide plan to guide the management of mountain lions. Current management efforts (described in USDI 1997) focus on the maintenance of critical wildlife water sources for bighorn sheep, and, in annual coordination with the AGFD, monitoring desert bighorn sheep and mule deer numbers, setting the number of hunt permits, and considering desert bighorn sheep transplants to augment populations elsewhere. Research on wildlife and wildlife water sources would continue. Collection of mountain lion scat for composition analysis and the radio collaring of mountain lions and desert bighorn sheep could continue. The study of desert bighorn sheep health and causes of mortality on the Refuge would also continue.

The Service would not take action to prevent mountain lion predation on desert bighorn sheep within the Refuge boundaries under this alternative.

3.2 Alternative B: the Proposed Action Alternative – Conduct Limited Removal of Mountain Lions

The proposed action is to allow the Service the option of removing specific individually-identified offending mountain lions, through translocation or lethal removal, from the Refuge under certain circumstances to recover and maintain an optimal population of desert bighorn sheep.

The proposed action has several components:

1. When the Refuge bighorn sheep population estimate is below 600 animals, active mountain lion control would occur, absent any significant mitigating circumstances. Active mountain lion control is the removal (lethal or translocation) of radio-collared

mountain lions found to kill two or more bighorn sheep within a 6 month period, as determined by investigation of predation sites. These sites are often identified by a cluster of GPS locations received from the satellite collar on the mountain lion. These mountain lions would be designated as "offending" mountain lions. The definition of "offending" mountain lion was modified from Ernest et al. (2002) and designed to target only mountain lions that establish a pattern of killing multiple bighorn sheep. Box traps, foot snares, or hounds may be used to assist in the removal of offending lions. Helicopters may be used to transport biologists to very remote locations to investigate possible kill sites or to place box traps. Aerial darting or net-gun capture of mountain lions may take place. Lethal removal or translocation would be carried out in the most efficient and humane way available. If killed, the lion would be retained for scientific analysis.

2. When the Refuge bighorn sheep population estimate is at or above 800 animals, active mountain lion control would not occur, absent any significant mitigating circumstances. Mountain lions on the Refuge may continue to be captured and fitted with satellite GPS collars to aid in continuing research.

3. When the Refuge bighorn sheep population estimate is between 600 and 800 animals, active mountain lion control may or may not be employed based on the totality of the circumstances at the time. In order to meet the bighorn sheep population objectives while minimizing the necessary impacts to mountain lions, some flexibility is warranted when the sheep population is at this stage. Decisions regarding whether active mountain lion control is necessary will be based on an adaptive management approach and based on the following factors:

    a. The current sheep population estimate.
    b. The current sheep population trend (an increasing or decreasing population trend of the bighorn sheep herd based on the prior 3 surveys [annual or triennial as funding allows]).
    c. Bighorn sheep lamb survival and recruitment.
    d. The minimum population estimate for mountain lions using the Refuge The level of predation by individual mountain lions currently using the Refuge. Offending mountain lions could continue to be removed under the existing criteria, or less stringent criteria could be used where mountain lions found to kill four or more bighorn sheep annually could be removed, depending on factors a-h.
    e. Current and forecasted habitat conditions.
    f. Available funding and manpower.
    g. Level of criticality of anticipated translocations

4. Translocation of offending mountain lions may be an option though it is not anticipated to be a viable option in most circumstances. This is based on the costs and logistical challenges associated with capture and transport of animals within and to remote areas, the sociopolitical challenges associated with locating appropriate release sites, hazards to the translocated animal, social disruption and possible exposure to foreign pathogens in the receiving population, and the fact that mountain lion populations are stable in Arizona with no known need to repopulate lions in any part of the state. Any potential

translocation will be done in coordination with the AGFD, in compliance with their regulations. Any translocated offending lions that return to the Refuge may be lethally removed from the Refuge using means outlined above.

5. The Service and AGFD would monitor and adaptively manage the program by assessing impacts of removing mountain lions on the overall mountain lion population and on the bighorn sheep population. This would be accomplished by assessing 1) the population estimate of bighorn sheep through annual surveys, 2) causes of mortality and assessment of mortality impacts to the bighorn sheep population, through ongoing cooperative research and monitoring projects and 3) ongoing assessment of mountain lion minimum numbers, diet and distribution. A regional cooperative research project to determine the status, distribution, and diet of mountain lions throughout southwestern Arizona using genetic analysis is currently partially funded and anticipated to be initiated in 2010. Should any of these assessments indicate that mountain lion predation is not (or is no longer) the limiting factor on the bighorn sheep population, or that mountain lion removals are not having the desired effect, this program will be reassessed.

The proposed action would include a number of measures to minimize animal suffering as much as possible. Any personnel involved in captures, translocations, or lethal removals will be trained and qualified in capture and handling methods specific to large felids, including correct dosing procedures, monitoring of vital signs, reversal of chemical immobilization, and ensuring the animal is fully recovered before departing the capture area. The equipment used would include pan tension devices and chemical immobilization or euthanasia procedures that would minimize or not cause pain. Although the inadvertent death of a mountain lion during capture and chemical immobilization is possible, the protocols used have been developed from hundreds of capture attempts in previous mountain lion research studies and have demonstrated no adverse effects in the four previous captures on the Refuge. Therefore, humane treatment of mountain lions would be emphasized, injuries would be minimized, and selectivity maximized. Research continues to improve selectivity and humaneness of management devices (USDA, 1997).

The Service would follow American Veterinary Medical Association (AVMA) recommendations for humane animal treatment (AVMA 1993, Beaver *et al*. 2001) , AGFD Article 3 (R12-4-301 through 319) on the Taking and Handling of Wildlife, and AGFD Policy on Captivity Standards (R12-4-248) as applicable The AVMA states that euthanasia is the act of inducing a humane death in an animal, and the technique should minimize any stress and anxiety experienced by the animal prior to unconsciousness (Beaver *et al*. 2001). Some people would prefer accepted methods of euthanasia be used when killing all animals, including wild animals. The AVMA states that for wild and feral animals, many of the recommended methods of euthanasia for captive animals are not feasible. In field circumstances, wildlife biologists generally do not use the term euthanasia, but use terms such as killing, collecting, or harvesting, recognizing that a distress-free death may not be possible (Beaver *et al*. 2001). Thus, AVMA euthanasia methods were developed principally for companion animals, and not for free-roaming wildlife. However, the AVMA (1993) considers under some circumstances a gunshot to the head or neck to be the only practical and acceptable method of euthanasia. They recommend it be performed by highly skilled personnel using a firearm appropriate for the situation (AVMA 1993). This would be the predominant method for lethal removal of mountain lions. Any mountain lions that are captured alive and slated for lethal removal or that are captured and found to be injured to the degree they

cannot survive would be euthanized by gunshot to the head or neck. Euthanizing drugs might also be used following methods recommended by the AVMA (AVMA 1993, Beaver *et al*. 2001).

3.3 Alternative C – Indiscriminate Removal of Mountain Lions

Under this alternative, there would be no attempts to radio collar and distinguish "offending" mountain lions. Mountain lions would be lethally removed or captured and translocated out of the area of the Kofa Mountains Complex (Kofa, New Water, South Plomosa, Tank, Little Horn, and Castle Dome Mountains). Efforts would be made to remove approximately two mountain lions per year from the area until the sheep population reached approximately 800 animals and exhibited an increasing trend based on at least 3 sheep population surveys. Mountain lion removals would resume if the desert bighorn sheep population was found to again go below 800 animals. Lethal removal and translocation techniques would be identical to those in the preferred alternative.

Under this alternative, the indiscriminate removal of mountain lions would meet the majority of objectives stated in Section 1.5. Although Ernest et al (2002) indicated that the indiscriminate removal of mountain lions reduces the risk of extinction of bighorn sheep, it also may not necessarily remove the mountain lions that regularly kill bighorn, or unnecessarily remove mountain lions that do not regularly kill bighorn.

3.4 Alternatives Considered But Not Analyzed in Detail with Rationale

Several alternatives were considered but not analyzed in detail. The alternatives eliminated from detailed consideration are described in Sections 3.4.1, 3.4.2, and 3.4.3, along with the rationale for their dismissal.

3.4.1 Sport Hunting Alternative

Sport hunting of mountain lions was considered as an alternative to reduce the impact of mountain lion predation on desert bighorn sheep, but was rejected because of its ineffectiveness in reducing abundance of mountain lions and decreasing predation of desert bighorn sheep (T. McKinney, AGFD, unpubl. data). Arizona's statewide population of mountain lions is estimated to be about 2,500 animals. Since 1990, between 210 and 325 mountain lions are taken by sport hunting annually in Arizona. Since 1982, mountain lion hunters have been required to contact the AGFD within 48 hours of taking a lion (AGFD 2007). Within 10 days of taking a lion, a hunter must submit for inspection the lion's skull, hide, and attached proof of sex. A tooth from the skull is taken during the inspection in order to accurately determine the age of the animal. Mountain lion hunters are permitted to take one lion per day until the harvest objectives for the particular game management unit or units is reached, but may not take spotted kittens or female mountain lions accompanied by spotted kittens. Hunters must call the AGFD prior to hunting to learn whether or not the harvest objective has already been attained.

A year-long mountain lion season for the game management units surrounding the Refuge was established in July 1996, and included units 16A, 40B, 41, 43A, 43B, and 44B. The harvest objective for this area was set at one lion total. From 1996 through 2007, no lions in this area were reported to have been taken by hunters (R. Henry, AGFD, pers. comm. 2008, AGFD 2007).

Beginning with the 2007-2008 hunt season, those game management units were added to the statewide hunt units and lion hunting was restricted in the statewide hunt to September 1, 2007 to May 31, 2008. The statewide hunt has no harvest objective; hunters are limited to one lion per calendar year. Service personnel, in coordination with the AGFD will monitor take from sport hunters, but believe that this will continue to be minimal, if any.

Very few mountain lions are taken in the desert portions of Arizona by sport hunters. For example, only one lion was reported taken by a sport hunter in game management unit 44A between 2002 and 2006, which includes the Harquahala and Harcuvar Mountains, areas that are known to have mountain lions (AGFD 2006). One factor that may be related is that most lion hunters use dogs to help locate mountain lions. In 2007, 163 of the 250 mountain lions harvested in Arizona were taken with the aid of dogs (AGFD 2008). However, dogs traveling in the deserts of southwestern Arizona suffer from contacts with cactus spines and sharp rocks. The usual hot and dry conditions also limit a dog's ability to use scent in tracking (R. Thompson, AGFD Predator Specialist, Phoenix, pers. comm., 2009). The low density and secretive nature of mountain lions limit the ability of hunters to harvest them without the use of dogs.

The addition of mountain lion sport hunting would expand hunter opportunities on the Refuge but for the reasons discussed above, not result in the taking of many, if any, mountain lions. Therefore, sport hunting of mountain lions was eliminated from further consideration as a method of affecting changes in lion or sheep populations.

3.4.2 Translocation of All Offending Mountain Lions Alternative.

Although translocation is not necessarily precluded, in many cases it would be logistically impractical and biologically unwise. Translocation of some animals is included in the proposed action, but few mountain lions would likely be relocated. Translocation of wildlife is often discouraged because many factors can affect the outcome (stress to the relocated animal, poor survival rates, and difficulties in adapting to new locations or habitats) (Ruth et al. 1998). Translocation may be appropriate in some situations if mountain lions are of a suitable age for relocation (two to three years old), suitable relocation sites are available, and funding required for relocation is available. However, mountain lions are relatively abundant in most locations of Arizona where populations exist and translocation is not necessary for the maintenance of viable populations. Relocation may also result in future depredations if the relocated animal encounters bighorn sheep in other areas of Arizona. Any decisions on relocation of wildlife by the Service are coordinated with AGFD and consultation with the appropriate land management agencies or managers associated with proposed release sites. It should be noted that the AVMA, the National Association of State Public Health Veterinarians, and the Council of State and Territorial Epidemiologists oppose the relocation of mammals due to the potential for disease transmission to a healthy local population. The Service and AGFD are aware of this potential and would take precautions to minimize disease transfer to another population during translocations.

3.4.3 Nonlethal Harassment Only Alternative.

Under this alternative, offending mountain lions would be harassed by first treeing them with dogs, then shooting them with rubber bullets and/or fitting them with electronic shock collars

and releasing them. Hebert and Lay (1996) made the case that mountain lions harassed would associate the area with negative stimuli and leave. Koehler et al. (1990) found that visual and acoustic stimuli such as scarecrows, loud music, and recordings of barking dogs had been tried with little evidence of efficacy against felids. The rubber bullets were not especially effective for black bears (*Ursus americanus*), but did work for a third of the nuisance bears. These methods are labor intensive and require people in the field much more frequently to monitor for mountain lions in the area of bighorn sheep. Several studies described that the closer and more frequent the human disturbance to bighorn sheep, the further they moved away from the source of disturbance (Krausman and Hevert 1983, Papouchis et al. 2001). This raises the concern that bighorns may move away from the disturbance into areas more conducive to predators or with less desirable habitat conditions. Therefore, it has been determined that currently available aversive conditioning methods are not likely to be effective for mountain lions and that the additional activity could disrupt sheep behavior, reducing the effectiveness of the desired outcome. Thus this potential alternative was dropped from further analysis. However, any new and improved aversive techniques will be considered in the future if they show promise in being highly effective in reducing bighorn sheep mortality caused by mountain lions.

4.0 AFFECTED ENVIRONMENT

This section describes the general environmental setting of the Refuge and focuses on the affected environment for the proposed action. The characterization of existing conditions provides a baseline for assessing potential environmental impacts from the proposed activities.

4.1 Climate and Setting

The Refuge is located in a low-elevation, hot, and arid desert: the Sonoran Desert, in the southwest corner of Arizona. Clear skies, low relative humidity, low rainfall, and wide daily temperature variations (high daytime temperatures with much lower nighttime temperatures) characterize the climate. Meteorological records indicate that the average daily temperatures range from 80°F to well over 100°F during summer months and from 40°F to 65°F during winter months. Average yearly precipitation at the Kofa Mine Weather Station is six inches. Typically, two “rainy” seasons provide the bulk of the rainfall: July through September (monsoon) and December through March. April through June is usually extremely dry while October and November are somewhat variable, but tend to be dry as well. Average yearly temperature and precipitation at the Kofa Mine weather station are given in Figure 3. Prevailing winds are from the north-northwest during autumn until early spring. As temperatures warm, winds shift to a more southerly direction. Winds associated with summer monsoons shift more toward the southeast. There are no perennial lakes or streams within the boundaries of the Refuge, although there are 10 known active springs and 63 named dams, impoundments, natural rock pools, modified rock pools, and wells.

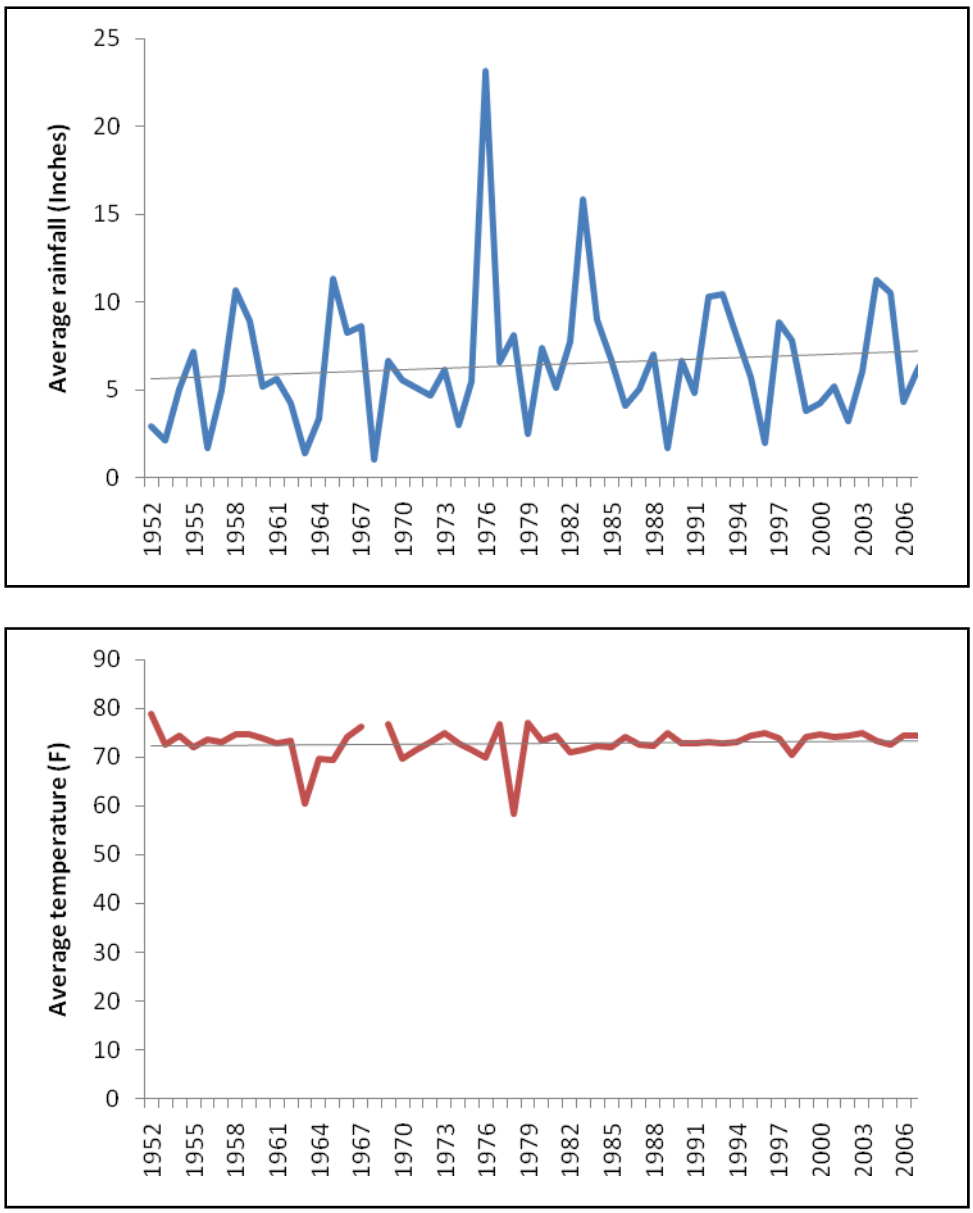

Figure 3. Average yearly temperature and precipitation at the Kofa Mine weather station, 1952-2008. Grey line represents data trend.

The Refuge displays a relief of two major block-faulted mountain ranges (Kofa and Castle Dome Mountains, and portions of the Little Horn, Tank, and New Water Mountains) typified by extensive exposures of bedrock, sparse vegetative cover, lack of soil development, steep slopes and structurally controlled drainage systems. Elevations range from 680 feet on the desert floor to 4,877 feet atop Signal Peak. Shallow, stony soils and rock outcrops are predominant in the mountainous and steep slope areas. Alluvial fans and valley floors are characterized by deep, gravelly, moderately fine textured soils high in lime concentrations.

The town of Quartzsite is located about 10 miles northwest of the Refuge and is the nearest population center, and the City of Yuma is located about 36 miles to the southwest.

4.2 Vegetation

More than 400 taxa of flora are found on the Refuge. The dominant perennial vegetation of the area includes creosote (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), ocotillo (*Fouqueria splendens*), ironwood (*Olneya tesota*), jojoba (*Simmondsia chinensis*), honey mesquite *(Prosopis juliflora*), desert lavender (*Hyptis emoryi*), catclaw (*Acacia greggii*), foothills paloverde (*Parkinsonia microphyllum*) and blue paloverde (*Parkinsonia floridum*).

4.3 Wildlife

The refuge hosts a diversity of wildlife species. The species found in the area are primarily those that are common to the mountains and bajadas of the Sonoran Desert. This includes species such as Gambel's Quail (*Callipepla gambelii*), White-winged and Mourning Dove (*Zenaida asiatica* and *Z. macroura*), Red-tailed Hawk (*Buteo jamaicensis*), numerous passerine species such as Verdin (*Auriparus flaviceps*) and Canyon Towhee (*Pipilo focus*), desert bighorn sheep, mule deer, desert cottontail (*Sylvilagus auduboni*), coyote, ringtail (*Bassariscus astutus*), gray fox (*Urocyon cineroargenteus*) western diamondback rattlesnakes (*Crotalus atrox*), kingsnakes (*Lampropeltus getulus*), side-blotched lizard (*Uta stansburiana*), and western whiptail lizard (*Aspidoscelis tigris*). In all, 193 species of birds, 49 species of mammals, and 41 species of reptiles and amphibians have been documented on the Refuge (USDI 2007).

The mule deer population on the Refuge is estimated each January by the Refuge and AGFD cooperatively, using both fixed-wing and helicopter surveys. The average deer population estimate from 1995-2009 is 752 animals, with a range from 362 animals in 1998 to 1114 animals in 2004. The 2009 population estimate is 583 animals (Figure 4). Mule deer regularly have twin fawns (Schmidt and Gilbert 1978), which allows their numbers to rebound from population lows more readily than bighorn sheep. Male mule deer, or bucks, may be hunted by a limited number of sportsmen during a regular rifle season in late October or early November and an archery season in January. Hunters usually harvest about 40 desert mule deer from the Refuge annually.

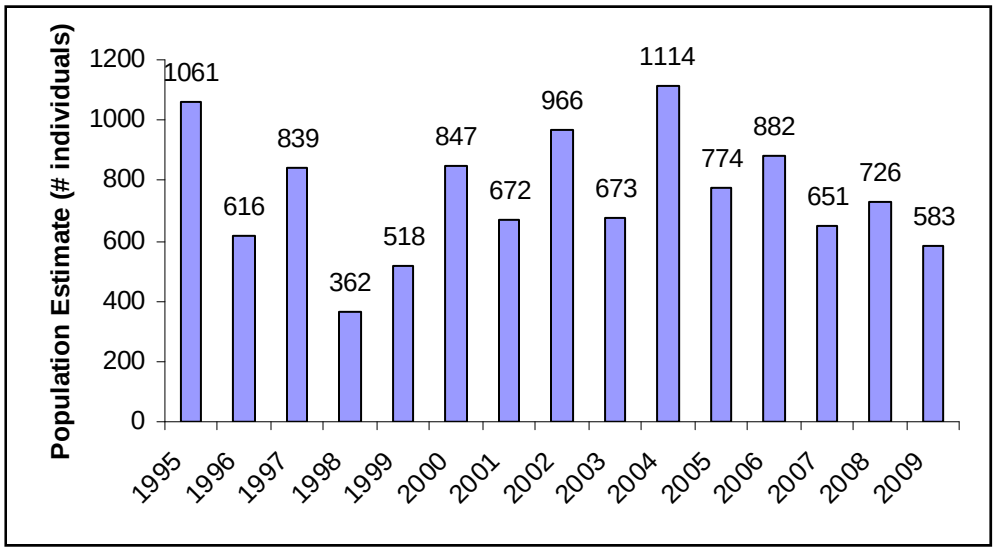

Figure 4. Refuge mule deer population estimates, 1995-2009.

The mule deer population historically demonstrates high variability from year to year, which is thought to be tied largely to rainfall and habitat conditions. For example, the sharp population drop from 1997 to 1998 was most likely due to the severe drought that occurred in 1997. There has been no severe "crash" in deer numbers observed recently that might precipitate prey switching from deer to bighorn sheep in mountain lions, nor is mountain lion predation thought to be a significant limiting factor on the mule deer population, although data from the collared lions and preliminary scat analysis data indicate that mule deer are an important, if not the majority, species in mountain lion diets on the refuge.

4.4 Threatened and Endangered Wildlife and Plants

No Federally designated threatened or endangered species are known to occur within the proposed project area. Ten other species occur on the Refuge that are on the AGFD list of Wildlife of Special Concern. These species have some status of concern, but no formal protection, and are listed in Appendix A. None of the 11 species' populations listed in Table A1 are anticipated to be adversely effected under any of the alternatives analyzed in this EA.

4.5 Mountain Lions

4.5.1 Background. Mountain lions, also known as pumas, or cougars, have historically had the broadest geographic distribution of any terrestrial mammal in the western hemisphere, except for humans (Logan and Sweanor, 2001). Mountain lions have occupied almost every type of biogeographic zone, including boreal foothills, temperate mountains and forests, tropical rainforests, grasslands, and deserts (Young 1946) along an elevation gradient ranging from sea level to 3,350 m in North America (Nowak 1991). By the late 1800s in North America, eastern populations were extinct or severely reduced, and by the early 1900s, western populations were diminished (Nowak 1976), to a contraction to about one-half of their modern geographic range (Logan and Sweanor 2000).

Although extirpated from much of the eastern United States, a sub-population still exists in southern Florida, and immigrant mountain lions have been documented recently in Georgia and New England (The Cougar Network, http://easterncougarnetwork.org/bigpicture.html, last visited 11/17/2009). Despite public sentiment up through the mid-1900s that favored the extermination of large predators such as the mountain lion through government and bounty programs, mountain lions have survived throughout the western United States and are now reoccupying some of their former range in the Midwest and eastern United States (The Cougar Network, http://cougarnet.org/bigpicture.html, last visited 11/17/2009).

The AGFD estimates that there are between 2,500 and 3,000 mountain lions in the State of Arizona. The Yuma puma is no longer considered to be a valid subspecies of mountain lion; in fact, all mountain lions in North America are considered to be the same subspecies (Culver et al. 2000, McIvor et al. 1995).

4.5.2 Mountain Lion Densities, Home Range, and Life History. Mountain lion density is related closely to prey availability and the social tolerance for other mountain lions. Prey availability directly influences mountain lion nutritional health, and reproductive and mortality rates. Studies indicate that as available prey increases, so do mountain lion populations. As mountain lion population density increases, mortality rates from intra-specific fighting and

cannibalism also increase, and/or mountain lions disperse into unoccupied or less densely occupied habitat. The relationship of the mountain lion to its prey and to other lions is why their densities do not reach levels observed in a number of other wildlife species (ODFW 1993).

Mountain lion densities in other states, based on a variety of population estimating techniques, range from a low of about 0.98 lions/100 mi^2 to a high of 23 lions/100 mi^2 (Johnson and Strickland 1992). An average density estimate for the western states was 7.3 lions/100 mi^2 (Johnson and Strickland, 1992). In the Southwest, reported mountain lion densities have ranged from 1.76 lions/100 mi^2 to 6.9 lions/100 mi^2 (Shaw 1977, Shaw 1980, Cunningham et al. 1995, Logan and Sweanor 2001)

Individual resident mountain lions can have very large home ranges, averaging 15-31 square miles (40-80 square kilometers) for females and 25-35 square miles (65-90 square kilometers) for males (Schmidt and Gilbert, eds. 1978). One male lion in California was recorded to have a home range of 174 square miles (450 square kilometers) (Christensen and Fisher 1976). Desert mountain lions tend to have larger home ranges: in the San Andres Mountains of New Mexico, the average adult male home range was 74.6 mi^2, ranging from 22.8 to 246.9 mi^2 (Logan and Sweanor 2001). The average adult female home range was 26.9 mi^2, ranging from 5.05 to 110.9 mi^2.

The mountain lions collared on the Refuge have roamed over very large areas on and off the Refuge, including the Kofa, New Water, Tank, Little Horn, Eagletail, Castle Dome, and Palomas mountain ranges. Although there is not enough data available to determine their home ranges, the mountain lions collared on the Refuge ranged over areas encompassing 290 mi^2 to 887 mi^2.

Female mountain lions typically breed for the first time between 21 and 29 months of age (Ashman et al. 1983, Logan and Sweanor 2001). Mountain lions can have litters of kittens in any month of the year, and litter size ranges from 1 to 6, with an average of about 2.6 (Robinette 1961). Normal habits of mountain lions minimize the possibility that diseases or parasites will limit the size of any mountain lion population. These habits include: (1) using dens for only short periods, (2) not using any bedding in dens, (3) avoiding spoiled meat, (4) seeking isolation except in breeding and rearing, (5) remaining almost continuously mobile, and (6) occurring in low densities (Schmidt and Gilbert, eds. 1978). However, mountain lions are subject to infectious diseases and parasites with several cases of plague having been documented in recent years (University of Wyoming, 2008).

The frequency of kills by mountain lions varies depending on the individual lion's hunting skill, disposition, sex, presence of kittens, availability and type of prey, season of year, and correspondingly, the rate at which meat spoils (Shaw 1977).

Mountain lions are not readily observed from the air or ground, and their nocturnal habits make them difficult to observe. The only methods available for determining mountain lion numbers are prohibitively time-consuming and expensive, usually involving a combination of intensive camera trapping, hound tracking, track surveys, and attempting to census a population by collaring all individuals in an area. For this reason, systematic surveys are few and reliable population estimates for large areas (such as statewide) do not exist.

4.5.3 Mountain Lion Occurrence on the Refuge. Mountain lions have historically been suspected to be largely transient on the Refuge. There were no verified records of mountain lions on the Refuge until a Bureau of Sport Fisheries and Wildlife employee killed a male mountain lion near Squaw Tank in 1944 (Halloran and Blanchard 1945). There were no additional verified records between 1944 and 2001. In 2001, a mountain lion-killed mule deer was found in the Castle Dome Mountains, and a mountain lion was observed on remote video in the Kofa Mountains. Subsequent investigations have verified the continual presence of mountain lions on the Refuge since that time.

It is worth noting that multiple investigations prior to 2001 did not reveal the presence of mountain lions on the Refuge. Shaw et al. (1988) found no lion sign along nine transects on the Refuge, nor any along the additional nine transects in nearby areas of the Lower Colorado River Valley subdivision of Sonoran desert scrub vegetation (Game Management Units 40, 41, and 46). During an AGFD research project in the Kofa Mountains from 1993 through 1996, approximately 6% (50) of the approximately 750 bighorn sheep were radio-collared and 17 mortalities were investigated. These mortalities showed no signs of predation and were attributed to either drowning or unknown causes, likely disease or malnutrition. From 1995-1997, Germaine et al. (2000) conducted track surveys for mountain lions in 18 mountain ranges and along the Colorado and Gila rivers in southwestern Arizona, including the Refuge. They confirmed the presence of only 3 individual mountain lions (in the Mohawk and Growler Mountains southeast of the Refuge) believed to be males, and suggested that a distinct, self-sustaining mountain lion population did not currently exist in southwestern Arizona. They found no evidence of lions on the Refuge.

Three mountain lions believed to be a female and two nearly-grown kittens were observed from a helicopter during a bighorn sheep survey in 2003. Since remote cameras were placed at water sources on the Refuge in 2003, mountain lions, including spotted juveniles and at least one female with kittens, have regularly been photographed. The Service has obtained 174 photographs of mountain lions since 2004.

Three cache sites were found on the Refuge between 2001 and 2007 (prior to any lions being radio-collared) and contained one mule deer, one bighorn sheep, and one badger. Mountain lions are also opportunistic scavengers, and some cache sites may be the result of lions scavenging upon animals they did not kill (Bauer et al. 2005). Six more lion kills identified opportunistically (not in conjunction with GPS monitoring) on the Refuge from 2005 to 2008 included five mule deer and one bighorn sheep. Animals killed by lions can be distinguished from animals that die from other causes. Tooth marks (canine punctures), hemorrhaging at the wound sites in the muscle or under the skin, splashes of blood on the surrounding terrain, disturbed soil and rocks indicating a struggle, evidence of asphyxiation or a broken neck, consumption of the nose and the ends of the ribs, removal and separate burial of the intestinal tract, as well as the carcass being dragged, placed under a tree or partially buried by rocks and sticks are all indicator that a mountain lion was the cause of death (Shaw et al. 2007).

4.5.4 Radio-collared Mountain Lions. Four mountain lions have been captured on the Refuge and fitted with GPS satellite radio collars and their movements monitored. A synopsis of the information gained from each of these lions is as follows:

KM01 – This male mountain lion was captured and fitted with a satellite GPS radio collar in April 2007. In June 2007, KM01 was determined to have met the offending lion criteria defined in the *Kofa Mountains Complex Predation Management Plan* (AGFD 2007). and was lethally removed by the AGFD on BLM-managed public land adjacent to the Refuge It was later determined by examining data from this lion's collar that KM01 had killed five bighorn sheep in three months. KM01 ranged over an area encompassing 573 mi^2 during the time he was collared.

KM02- This male mountain lion was captured a fitted with a satellite GPS radio collar in June 2007. During the two months that the lion had a collar, it was found to kill two coyotes, four mule deer, and one desert bighorn sheep ewe. The ewe was killed in the Palomas Mountains, outside of the area covered in the AGFD's *Kofa Mountains Complex Predation Management Plan***.** In late July, 2007, a release mechanism on KM02's collar failed and the collar fell off before its programmed release date. The collar was recovered, but attempts to recapture and replace the collar on this lion have been unsuccessful. KM02 ranged over an area encompassing 290 mi^2 during the time he was collared.

KM03 – This male mountain lion was captured and fitted with a satellite GPS radio collar in October 2007. In March 2008, KM03 was determined to have met the offending lion criteria and was lethally removed by the AGFD off the Refuge on the Yuma Proving Ground. Investigation of GPS data from KM03's collar revealed that he had killed six bighorn sheep in the five months that he was collared, including one satellite-collared ewe (from the USGS New Mexico Cooperative Research Unit effort – See Section 4.6.3). KM03 ranged over and area encompassing 382 mi^2 during the time he was collared.

KM04 – This male mountain lion was captured on the Refuge and fitted with a satellite GPS radio collar in February 2009. By March 2009, KM04 had met the offending lion criteria. In September 2009, KM04 was lethally removed by the AGFD off the Refuge on BLM-managed public land. During the 6 months KM04 was collared, he killed 16 bighorn sheep (including one satellite-collared ewe), 2 mule deer, and one unidentified fox species (gray or kit). KM04 ranged over and area encompassing 887 mi^2 during the time he was collared.

It was noted that all four collared lions, KM01, KM02, KM03 and KM04, moved on and off the Refuge regularly. Each lion killed and consumed a large animal (mule deer or bighorn sheep) every 5.4 days on average (ranging from one to12 days). Based on the field examination of GPS cluster locations, all four lions together killed and consumed 17 mule deer, 28 bighorn sheep, two badgers, one fox, and two coyotes during the time they were being monitored.

4.5.5. Mountain Lion Genetics and Scat Composition Analysis. DNA and composition analysis of lion and bobcat scat is being completed by a researcher and graduate student from the USGS Arizona Cooperative Research Unit. About half of the DNA-confirmed mountain lion scats have been analyzed so far, and preliminary results from scat collected on the Refuge revealed mule deer, desert bighorn sheep, badger, gray fox, and domestic sheep (*Ovis aries*) as prey items. Black-tailed jackrabbit (*Lepus californicus*) has been the only prey item identified in

bobcat scat so far, but neither this analysis nor the mountain lion diet analysis is complete. Diet analysis is ongoing and should be completed by January 2010.

Individual genetic profiles are also being processed from mountain lion scat collected on the refuge from 2007-2009. As of August 2009, 11 unique mountain lion genotypes have been identified from scat and tissue samples collected on Kofa NWR. This includes the four mountain lions that were collared. Nine genotypes were identified from scat collected in the Kofa Mountains, which included the genotypes of KM01, KM03, and KM04, plus two additional males, one female, and three genotypes for which sex could not be determined. Two genotypes were identified from scat collected in the Castle Dome Mountains, which were the genotypes of KM02 and another female. Preliminary data suggest that an uncollared male from the Kofa Mountains and the two females were related (most likely an adult female and her male and female offspring), although this needs to be confirmed by more specific testing. Complete relatedness analysis for all genotypes identified should be completed by January 2010.

Collaring efforts and scat DNA analysis have also established the presence of two additional individual mountain lions east of the Refuge. A male mountain lion (RM01) was captured and collared by the AGFD in the Gila Bend Mountains in 2008. DNA analysis from scat collected on BLM land near the eastern edge of the Tank Mountains produced the genotype of a female. Her range and current status is unknown, although she could be using the Refuge.

Although density and the fate of all the individuals identified is not known, genetic analyses so far suggest that mountain lions using the Refuge are not rare, isolated, or unique.

4.6 Desert Bighorn Sheep

4.6.1 Background. Bighorn sheep occupy portions of the western United States and southern Canada, from British Columbia to New Mexico and into portions of Mexico including Baja California, Sonora, and Chihuahua (Schmidt and Gilbert, eds. 1978). Desert bighorn sheep are found in southeastern California, southern Nevada, Arizona, and portions of New Mexico. The largest contiguous block of habitat for desert bighorn sheep of the subspecies *mexicana* (*O.c. mexicana*) in Arizona is the Kofa, New Water, Plomosa, Little Horn, Castle Dome, and Tank Mountains, sometimes referred to as the Kofa Mountains Complex. The Refuge covers a majority of this area.

4.6.2 Life History. Bighorn sheep have life history traits such as slow growth rates, late maturation, long gestation, low fecundity, and long lives (Remington 1989). Their social structure revolves around retention of juveniles on the home ranges of adults, versus dispersal of young from adult home ranges. Bighorns have low rates of population growth, which means their ability to recover rapidly from herd depletion is much less than other species (Geist 1975). Deer (*Odocoileus spp.*), on the other hand, are adapted to exploit early successional habitats and reproduce at an early age, produce more offspring with relatively lower survival rates, but generally have the ability to recover rapidly after depletion (Krebs 1972). Thus bighorn sheep appear to be more vulnerable to population declines and extinction than species with life history traits like deer.

Bighorns have evolved population maintenance strategies that revolve around social mechanisms that transmit home ranges and migratory patterns from one generation to the next (Geist 1975). Rather than expulsion of juveniles from the population, bighorn dispersal usually occurs irregularly through segmentation of herds when population densities are high. These behaviors are likely adaptations to the naturally fragmented habitats bighorn sheep occupy, but barriers such as development and roads have necessitated the capture and translocation of bighorn sheep to historic ranges to facilitate re-occupancy of historical habitat. By virtue of bighorn sheep ecology and compensatory mechanisms for population maintenance, recovery from population declines is an inherently slow process.

Bighorn sheep are primarily browsers and are able to consume a variety of plants to meet their dietary needs. They select foods based on their availability and palatability which may change from season to season and from year to year. During droughts or hot periods, the availability of water, such as found on the Refuge at water developments, springs, and natural rock waterholes, allows desert bighorn sheep to consume plants that have a lower moisture capacity (Geist 1975). Thus the ability of a particular area to support a number of desert bighorn sheep (or carrying capacity) varies depending on habitat conditions and water availability.

Table 2. Statewide desert bighorn sheep population estimates for Arizona as reported in the status reports in the *Desert Bighorn Council Transactions*.

Year	State of Arizona Desert Bighorn Sheep Population Estimate
1991	4500
1992	4500
1993	5500
1994	6000
1995	6500
1996	6500
1997	6000
1998	6000
2000	6000
2001	6000
2002	6000
2003	5500
2005	5500
2007	4500
2008	4500
2009	4500

Bighorn sheep have evolved a variety of behavioral adaptations to avoid predation. A stocky build and relatively short legs provide agility on steep and rugged terrain, but preclude the

fleetness necessary to escape predators in more gentle slopes. Another important adaptation is "group living" (Hamilton 1971, Alexander 1974). Groups provide more eyes and ears and enable members to spend more time feeding and less time surveying for predators. Studies of this phenomenon have found that a group size of six or more bighorn sheep confer an advantage in the proportion of time allocated to feeding (Berger 1978, Risenhoover and Bailey 1985). The selfish herd concept of Hamilton (1971) suggests that greater group sizes may confer further behavioral comfort. Bighorn sheep are primarily diurnal (Krausman et al. 1985), which,coupled with keen eyesight to detect predators, minimizes predation risks. Nights generally are spent on steep, rocky slopes.

4.6.3 Desert Bighorn Sheep Transplants. From 1955 to 2000, over 1,200 bighorn sheep were transplanted within Arizona (Lee et al. 2000), and bighorn populations increased from 2,500 to over 6,000 during that time. The first successful translocation of sheep from Kofa NWR was in 1957 when four bighorn were released at the Black Gap Wildlife Management Area in west Texas. From 1957 through 2006, 569 bighorn sheep have been translocated from the Refuge. The Kofa NWR bighorn herd has been essential as a source population for reestablishing and maintaining other bighorn herds in Arizona, including the Buckskin, Harcuvar, Eagletail, Sauceda, Superstition, and Peloncillo Mountains and desert bighorn herds in Texas, New Mexico, and Colorado. If the herd remains at current levels or continues to decline, bighorn sheep translocations cannot occur to repopulate historical bighorn sheep habitat.

4.6.4 Desert Bighorn Sheep Health and Causes of Mortality. Beginning in November 2007, the USGS New Mexico Cooperative Research Unit began a four-year study on the health and causes of mortality of desert bighorn sheep on the Refuge. The study began with the radio-collaring and initial health analysis of 27 ewes in November 2007. By November 2008, an additional 18 ewes were collared. Since 2007, 12 radio-collared ewes have died: nine deaths were attributed to mountain lion predation, and three were due to unknown causes that were not predation. Three collars have malfunctioned and stopped transmitting. In 2009, 23 ewes were recaptured and 11 additional ewes were collared and assessed. At the time of this writing, 40 collared ewes are alive and being monitored by a graduate research assistant and technician on a regular basis. An additional capture and re-assessment of the same animals is planned for November 2010.

Included in the health assessment of bighorn sheep was testing for disease. Analysis of biological samples taken at the time of their initial capture has shown that the animals have not been affected by pneumonia or pneumonia-like diseases. Eleven ewes gave positive titers for non-avian Chlamydia, twenty-five ewes gave positive titers for bovine respiratory syncytial virus (BRSV), and twenty-one gave positive titers for parainfluenza 3 (PI3). In all cases, the titers were low, indicating exposures but not active infection. All 30 bighorn captured in 2007 tested negative for Q fever, *Brucella ovis*, toxoplasma, and leptospirosis. These infections can cause abortion in bighorn sheep. Pregnancy testing indicated that 29 of the 30 ewes captured in 2007 were pregnant at the time of capture. This suggests that low lamb production is not tied to infertility, lack of impregnation, or abortion.

4.6.5 Desert Bighorn Population Modeling

Ungulate populations fluctuate naturally. Some causes of fluctuation include disease, habitat conditions, harvest, predation, immigration and emigration (Saether *et al.* 1997). Translocations are another source of population fluctuation on the Refuge. Of these, the Service can readily quantify harvest, translocations, and predation. Movements of numerous bighorn sheep between populations are unlikely (ruling out emigration as a major source of population decline), and tests for disease have not yet indicated any cause for concern. This leaves harvest, translocations, predation, and habitat conditions as the prominent factors. The Service, in cooperation with NMSU, is currently studying the relationship between habitat conditions and body condition of bighorn sheep on the Refuge. However, the highest priority of the Service was to examine the known immediate causes of bighorn sheep population reduction and determine which factors were capable of causing the magnitude of decline noted, as well as how long it might take the herd to recover if those factors were reduced or eliminated.

The Service, with assistance from the AGFD, has modeled the life history of the Refuge bighorn sheep herd and hypothesized scenarios of decline and recovery. The modeling is summarized in the following section, but the full document is attached in Appendix D. Appendix D contains all of the values used in the model and their sources.

The purpose of this modeling exercise is to evaluate the potential of predation to be a plausible factor in causing a rapid decline in the population of desert bighorn sheep on the Refuge. Here, a rapid decline is defined as a 50% reduction in the population over a 6 year period. This reported decline in the bighorn sheep population coincides with the recent documentation of breeding mountain lions that use the Refuge (Smythe 2008).

Our method relies on a simple population growth curve founded on demographic parameters measured from the Refuge bighorn sheep population and gained from the literature, so that the modeled population stabilizes at *K* (carrying capacity). For each time step in the model, we simulated predation by removing female and male bighorn sheep. We then quantified the response of the bighorn sheep population to these simulations.

This population, like most populations of ungulates, fluctuates in response to many internal and external factors (Sæther *et al.* 1997). Accounting for these fluctuations would involve a more complex model that incorporates variation in variables such as *K* and λ (finite rate of increase), while potentially including other terms to account for environmental stochasticity. Here, our intentions are not to generate such a model of the Refuge bighorn sheep population that incorporates multiple variables. Therefore, we are not determining what caused the bighorn sheep decline, nor can we conclude if predators are responsible for the decline. (As above, this objective would involve testing other variables, such as evaluating sheep numbers and precipitation levels [as a surrogate for forage quality or quantity] that could dampen or accentuate any decline). Instead, we generate a model of bighorn sheep numbers that stabilize at *K*, and then explore to what extent predation, and no other variables, could reduce bighorn sheep numbers. This analyses responds to the question "If predators are in fact the factor responsible for the decline, then what amount of predation would it take to cause the decline, and is this amount of predation reasonable given our understanding of the system?." Results then inform us the extent to which predation could be a contributing cause in reducing the Refuge population of desert bighorn sheep.

Methods

This model focuses on predation, and evaluates how varying levels of predation can reduce bighorn sheep populations. Harvest and translocations are also incorporated as known, fixed values. The goal was to determine which factors could reasonably cause the population decline observed within the time period noted. Analyses incorporate predation from one to four mountain lions with bighorn sheep populations modeled via a discrete growth logistic equation, to account for density dependence. Each level of predation contains 35 different scenarios, as predation can occur disparately across bighorn sheep age classes (*e.g.* only young bighorn sheep, only old bighorn sheep, mixtures of young and old etc.). The population response of the bighorn sheep herd is reported at six and 10 years time after predation begins, based on scenario averages. The model predicts the number of years necessary to halve the bighorn sheep population, if predation levels were unabated. Also simulated is the amount of time it takes a halved population of bighorn sheep to recover to pre-decline levels. The exercise concludes by comparing and contrasting models differing by mountain lion numbers and bighorn sheep population trajectories, seeking guidance on the amount of predation required to halve this population, and evaluating if such levels are biologically supported.

Results

Population decline

When harvest and translocations from 2000-2008 were modeled as the only removals from the bighorn sheep population, the scenario average indicated that the total population dropped from 800 bighorn sheep to 762 after six years, and recovered to 796 after 10 years (Table D3). This indicates that harvest and translocation alone would not account for the decline in bighorn sheep numbers observed on the Refuge.

When predation by one mountain lion was added, the average of 35 different predation scenarios indicates that the bighorn sheep population drops to 709 after six years and recovers to 726 after 10 years (Table D3). With predation by two mountain lions, the bighorn sheep population drops to 646 after 6 years and to 636 after 10 years (Table D3). Three to five mountain lions can halve the bighorn sheep population in six years (Table D3,).

The average scenario indicated that predation by at least three, and as many as five, mountain lions was required to halve the bighorn population in six years, depending on the sex and age class of bighorn sheep removed (Table D2). Predation by one or two lions was not sufficient to cause the decline noted in the time period observed.

Population recovery

Depending on the rate of population growth modeled (Table D1), a bighorn sheep herd with 400 animals would take anywhere from 11 to 50 years to recover to 800 animals, assuming all predation, translocation, and harvest were to cease.

Conclusions

Predation by three to five mountain lions has the potential to halve the Refuge desert bighorn sheep population in nearly six years. Overall, predation has the potential to reduce bighorn sheep numbers rapidly, and predation likely plays an important role in generating the bighorn sheep population decline observed on the Refuge.

The purpose of this modeling exercise was to examine the relationships between bighorn sheep removal (be it predation, harvest, or translocation) and bighorn sheep population response and size. Results herein demonstrate that three to five mountain lions can halve a population of 800 bighorn sheep in approximately six years. Unfortunately, recovery can be slow. At the rates of population increase that were modeled, it takes decades (11-50 years) for a population of 400 bighorn sheep to rebound (to about 800). These results send the same message: damage to bighorn sheep populations can happen quickly and it can take many years for bighorn sheep populations to recover.

The model indicates that the Refuge bighorn sheep population would be more resilient to predation were translocations not conducted. However, the main purpose for maintaining large numbers of bighorn sheep at the Refuge is for relocating sheep to augment or establish populations elsewhere. Harvest also removes bighorn sheep, but only males. These males contribute little to the overall numbers of bighorn sheep over time. Neither harvest nor translocations could account for the steep drop in bighorn sheep populations observed over a short time period.

Low levels of bighorn sheep at the Refuge stymies managers ability to augment or re-establish bighorn sheep populations, range-wide. Lessening our management options reduces the ability to augment ailing populations of bighorn sheep, many with populations remaining flat or in decline across the southwest (AGFD, unpublished data).

The model results do not infer that other factors, such as habitat quality or climate change, are not contributing to the Refuge bighorn sheep population decline. However, these effects would largely act additively in reducing the bighorn sheep population. They are being investigated elsewhere. Analyses herein simply illustrated that predation could be a cause in generating the reported decline in the Refuge bighorn sheep numbers.

4.6.6 Desert Bighorn Sheep Hunting. Hunting has been used as a population management tool for many species, including desert bighorn sheep. Monies generated from bighorn tags are used to fund population surveys and projects for bighorn sheep conservation, although these efforts require more dollars than are generated by bighorn hunting. Arizona's first bighorn sheep hunt was held in 1953 (AGFD 2006). Research in Alberta has shown that a healthy vigorous herd can be maintained by conservative harvest of mature rams and population maintenance below carrying capacity (Canadian Fish and Wildlife Service, 1993). Bighorn sheep hunters typically select the largest, hence the oldest, rams in the herd. In 2005, the average age of sheep taken in Arizona was seven years old, with an average Boone & Crockett green score of 152 3/8. In Arizona, bighorn sheep are harvested under a general, male-only open season. Hunters can take only one desert bighorn sheep in their lifetime and hunters must personally check out within three days following the close of the season in accordance with AGFD rule 12-4-308.

For the purposes of hunt management, AGFD has divided the state into a series of game management units (GMUs). The refuge is divided into three GMUs: GMU 45A comprises roughly the northwestern third of the refuge, GMU 45B the southeastern third, and GMU 45C the southwestern third. Other surrounding GMUs contain the remaining sections of the greater Kofa Mountains Complex. AGFD has issued five to 17 bighorn sheep permits for the Kofa GMUs since 1960. The hunter success rate has averaged 89% for bighorn sheep on the Refuge over the last 20 years. Currently, the number of desert bighorn sheep tags issued is equal to approximately 15% of the Class 3 and 4 rams found in the most recent surveys, although hunters may take any ram. Class 3 and 4 rams are six years old or older. The Arizona Game and Fish Commission has approved the issuance of six desert bighorn sheep tags for the Refuge for the December 2009 hunt, in addition to one tag issued in for the New Water Mountains that may be filled on or off the Refuge. Removal of a limited number of rams through hunting does not affect the reproductive potential of the population since bighorn rams may, and often do, breed with more than one ewe. Conflicts between rams over females during the breeding season are common and well documented (Monson and Sumner, eds. 1980).

4.7 Visual Resources

Visual resources are tied to both recreation and wilderness values. The Refuge has a predominantly natural appearance, except for several areas of surface disturbance or debris from past mining and exploration activities, roads, and a utility right-of-way on the north end that contains several gas pipelines with aboveground valves and a 500kV powerline, as well as a Department of Energy powerline that touches on the Refuge's western boundary. Visual resources within wilderness are managed to preserve the existing character of the landscape. Any changes to the wilderness characteristics by Refuge management should be very minor, repeating the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape, and should not attract attention.

4.8 Recreation

The Service allows a variety of recreational uses. The System is mandated to consider wildlife first in all management activities, with all public uses considered secondary. The National Wildlife Refuge System Improvement Act of 1997 identified six wildlife-dependent priority public uses to be generally appropriate on Refuges: hunting, fishing, wildlife observation, photography, environmental education, and interpretation. However, all public uses must undergo a compatibility analysis to determine if the uses are compatible with the purposes for which the Refuge was established and consistent with the System mission. A finding that funding is available for the management of these activities must be included in the analysis. Uses within designated wilderness must also conform to requirements of the Wilderness Act.

The majority of recreational use on the Refuge, including hunting, wildlife observation, hiking, climbing, and road exploration in four-wheel drive vehicles, occurs almost exclusively in the fall, winter, and spring months. The public is not permitted to drive vehicles more than 100 feet off of the designated roads regardless of whether or not the road is adjacent to wilderness. Hunters,

participating in any of the various hunting seasons, may presently hunt anywhere on the Refuge outside of private inholdings.

The Refuge hosts an estimated 50,000 - 60,000 visitor each year. Many visitors are members of the retirement community that spend the winter in the Yuma/Quartzsite area. Hunters are included in these totals and contribute approximately 2,000 visits per year. Tourism is one of the top two industries in Yuma (after agriculture), resulting in considerable socioeconomic benefit to the area. The Refuge contributes an estimated $8.5 million annually to the economy of La Paz and Yuma Counties (see Table 3). These monies create 106 full and part-time jobs and generate a total tax revenue, including federal, state, and county, of $891,000.

Table 3. Recreation expenditures ($/person) that were incurred by the public visiting Kofa NWR in 2004 (Caudill and Henderson 2005).

	Resident	Non-Resident	Total
Non-Consumptive	$2,651	$3,889	$6,541
Big Game	$49	$24	$73
Small Game	$31	$30	$61
Total Hunting	$80	$54	$134
Total Expenditures	$2,732	$3,943	$6,675

The Refuge also provides a positive cost:benefit with the taxpayer money that funds the Refuge. Overall, the Refuge brings $9 to the local area for every $1 spent by the Refuge, a $1:$9 cost benefit (Table 3).

Table 4. The cost:benefit of expenses, in thousands of dollars, incurred by Kofa NWR (Caudill and Henderson 2005).

Kofa NWR	FY 2004 Budget	Recreation Expenditures	Net Economic Value	Cost:Benefit Budget:Economic Benefit
	735	6,674.8	6,330.3	$1:$9.08

4.9 Wilderness

In 1990 the Arizona Desert Wilderness Act (Act) was enacted, establishing over 510,000 acres of designated wilderness on the Refuge. This law effectively mandated management that had been established when the area was designated as a wilderness study area in the mid-1970s. Vehicle use had been restricted to designated roads since 1976, but about 25 miles of roads were closed for all use with passage of the Act (more than 300 miles are still available for public use). In addition, mechanized equipment was prohibited from the wilderness areas.

The definition of Wilderness from Section 2(c) of the 1964 Wilderness Act identifies four qualities of wilderness related to wilderness character. All wilderness areas, regardless of size, location, or any other feature, are unified by this statutory definition of wilderness:

- Untrammeled – wilderness is essentially unhindered and free from modern human control or manipulation.

- Natural – wilderness ecological systems are substantially free from the effects of modern civilization.

- Undeveloped – wilderness is essentially without permanent improvements or modern human occupation.

- Outstanding opportunities for solitude or a primitive and unconfined type of recreation – wilderness provides outstanding opportunities for people to experience solitude or primitive and unconfined recreation, including the values of inspiration and physical and mental challenge.

The wilderness on the Refuge has a predominant natural appearance. However, there are several areas with surface disturbances or debris from past mining and exploration activities and from former vehicle routes. Regardless, the size and unique features of the Kofa Wilderness Area make it a valuable unit of the National Wilderness Preservation System.

5.0 ENVIRONMENTAL CONSEQUENCES

This EA reviews and documents the potential effects of implementing the proposed action and its alternatives on the physical, biological, and social aspects of the human environment. This section analyzes the direct, indirect, and cumulative environmental impacts or consequences that can reasonably be expected from the implementation of each of the three alternatives described in Section 3.0 of this EA.

Direct effects are the impacts that would be caused by the alternative at the same time and place as the action.

Indirect effects are impacts that occur later in time or distance from the triggering action.

Cumulative effects are incremental impacts resulting from other past, present, and reasonably foreseeable future actions, including those taken by federal and non-federal agencies, as well as undertaken by private individuals. Cumulative impacts may result from singularly minor but collectively significant actions taking place over a period of time. Cumulative impacts are the overall, net effects on a resource that arise from multiple actions. Impacts can "accumulate" spatially, when different actions affect different areas of the same resource. They can also accumulate over the course of time, from actions in the past, the present, and the future. Occasionally, different actions counterbalance one another, partially cancelling out each other's effects on a resource. But more typically, multiple effects add up, with each additional action contributing an incremental impact on the resource.

Because the proposed activities would occur in wilderness, a Minimum Requirements Decision Guide (MRDG) was completed to evaluate the alternatives. An MRDG is a decision-making process, documented in writing, which we use to determine if proposed refuge management activities conducted in wilderness are necessary to administer the area as wilderness and to accomplish the purposes of the refuge including Wilderness Act purposes. If the activities are necessary, the MRDG also describes how to minimize resultant impacts. The MRDG can be found in Appendix E of this document.

None of the Alternatives examined in this EA involve any kind of ground or vegetation disturbance, and therefore, these resources would not be impacted. Based on review of the proposed action, it was determined that the following resources would not be affected by the various alternatives, and do not require any additional analysis or further discussion in this EA:

Physical Considerations - climate and air quality; topography and soils; geology; hazardous, solid, or toxic wastes; water quality and quantity; floodplains: and wild and scenic rivers

Biological Considerations – vegetation; threatened or endangered species

Social Considerations - cultural or archaeological resources; Native American religious concerns; land use and ownership; prime or unique farmlands

The following analysis focuses on resources with the potential to be affected by the Alternatives.

5.1 Alternative A – No Action – Continue Current Management Efforts

Alternative A, the No Action Alternative, represents a continuation of current management practices and serves as the baseline against which other management alternatives are compared. The No Action Alternative has the potential to impact biological resources, considered in Sections 5.1.1, 5.1.2, and 5.1.3, and social factors considered in Sections 5.1.4, 5.1.5 and 5.1.6. There will be no direct impacts from this Alternative because no action will be taken. However, indirect impacts are discussed in the following sections.

5.1.1 Impact on Mountain Lion Populations**.** In this alternative, no mountain lions would be removed from the Refuge. Alternative A would be the most humane since no mountain lions on the Refuge would be subject to stress, discomfort, or direct or indirect mortality from translocations. Since it has been well documented that lions move on and off the Refuge, they would still be subject to removal by AGFD or hunters once off the Refuge. Lion density is dependent on prey availability and it is unlikely that a large population of lions could ever be supported on the Refuge, even without removals.

5.1.2 Impact on Bighorn Sheep Populations. As discussed in previous sections of this document, there is ample evidence that mountain lions can negatively impact bighorn sheep populations. Mountain lion predation appears to have the greatest impact on bighorn sheep herds when compounding factors are involved, such as a drought or decline in primary prey populations (mule deer). Many of these variables are difficult to quantify or predict. The

Service has constructed a life history model (see Section 4.6.5 and Appendix D) of the Kofa bighorn herd in an attempt to predict consequences of known impacts to bighorn sheep. This model indicates that although recent translocations and hunting could have contributed to a small decline in the population, those removals would not have caused the sharp decline noted from 2000-2006. However, mountain lion predation could have easily caused the magnitude of decline observed given the number of lions documented on the Refuge. The model also indicates that at the levels of predation observed from collared lions, the bighorn sheep herd would continue to decline. Sharp declines lead to loss of genetic diversity and vigor in the bighorn sheep herd and can make management and recovery difficult, possibly requiring drastic management actions, such as transplants of desert bighorn sheep from other areas to the Refuge. This alternative may further reduce the numbers of bighorn sheep. To further understand the impact of lion predation on the bighorn sheep herd, the Service has engaged in cooperative research with New Mexico State University examining causes of mortality of bighorn sheep and the effects on bighorn production and growth rates. The best available data now indicates that lion predation is an important factor: nine out of 12 mortalities of collared bighorn sheep on the refuge were attributed to lion predation, and each of the collared lions preyed upon a bighorn sheep at least once. Although mountain lion predation might not have been the sole cause of the decline from 2000-2006, (USFWS, unpublished data) lion predation may limit herd recovery from present levels by depressing production, and the model indicates that once down to small numbers, it may take decades for the population to recover. Under the No Action Alternative, it is probable that the bighorn sheep herd would decline, conceivably to extirpation, but more likely to low levels that may be difficult to recover. Transplanting desert bighorn sheep from the Refuge to augment or restore historical herds would not be possible. The limited hunt of desert bighorn sheep rams may not take place. If limited mountain lion control takes place off-Refuge, there may be some increase in bighorn sheep populations on the Refuge.

5.1.3 Impact on Non-target Species. Mountain lions on the Refuge would continue to take mule deer as their primary prey. Thus, mule deer could decline in number depending on the number of mountain lions that use the Refuge. Mule deer numbers are expected to change based on vegetation quality and quantity, the number of fawns born, hunting success, and the number of mountain lions on the Refuge. Implementation of the No Action Alternative is anticipated to have minimal potential to impact any other species.

5.1.4 Impact on Visual Resources and Recreation. The No Action Alternative would have no effect on visual resources. The No Action Alternative might affect recreational opportunities for hunters and wildlife watchers. If lions are impacting the bighorn sheep herd to the extent believed, a continued decline in the population would lessen the number of hunting permits issued and may eventually lead to the discontinuation of bighorn sheep hunting on the Refuge. Fewer sheep also means the likelihood of a visitor seeing bighorn sheep may be reduced. Fewer hunting permits may be available for mule deer hunters. The reduction in the availability of wildlife for both viewing and hunting would likely reduce the number of Refuge visitors, which would have an economic impact in the local area.

5.1.5 Impact to Wilderness Values. The No Action Alternative could be considered more consistent with wilderness values than the proposed action from the standpoint that natural

processes would be allowed to occur. However, what is considered "natural" on the Refuge is subjective and difficult to define. Bighorn sheep are also an important component of wilderness and should be maintained as such. If mountain lion predation is allowed to continue unchecked, the bighorn sheep herd could continue to decline. While it is unlikely that the bighorn sheep herd would be completely extirpated, it could drop to levels that require much more intensive, invasive management procedures to prevent extirpation, such as a translocation of sheep from outside the Refuge. These activities could reduce wilderness values in the long term. See the MRDG for a more detailed description of these impacts (Appendix E).

5.1.6 Other Considerations. Alternative A is the alternative most likely to meet the concerns of those individuals, agencies, and organizations that would prefer to see no limits on mountain lion predation on the Refuge.

If there are no limits placed on mountain lion predation on desert bighorn sheep on the Refuge, the desert bighorn sheep numbers are likely to decrease to low levels and the transplant and hunt programs would be suspended indefinitely. This might limit the funding donated (from all sources, including government and private) and effort expended on desert bighorn sheep conservation efforts on the Refuge.

Money from both agency and private sources would not be spent on the Refuge for the translocation or lethal removal of mountain lions.

5.1.7 Cumulative Impacts. For mountain lions and desert bighorn sheep, the cumulative impact of the No Action Alternative was considered statewide (for mountain lions) and within Arizona and New Mexico (for desert bighorn sheep). Under the No Action Alternative, the Refuge desert bighorn sheep populations may continue to decline. Arizona contains numerous isolated or semi-isolated bighorn sheep herds, and the desert bighorn population has been declining statewide (Table 4). The removal of three offending mountain lions (to date) from lands surrounding the Refuge is limited and has taken place so recently that significant increases of bighorn sheep have not yet been observed. It is expected that the removal of the three mountain lions would not likely impact the desert bighorn sheep population over time as it is anticipated that these lions will be replaced by new dispersing lions, and this may have taken place already. Mule deer populations may decline, depending on other factors, and there would be the impacts described in Section 5.1.5 to Wilderness values. The transplants of desert bighorn sheep from the Refuge described in Section 4.6.3 may remain suspended indefinitely, and this affects wildlife and land managers' ability to positively impact desert bighorn populations in both Arizona and New Mexico. Because the population model (Section 4.6.5 and Appendix D) shows that the desert bighorn sheep population on the Refuge may take up to 50 years to return to a population of 800 animals, these impacts would remain for up to 50 years, under the No Action Alternative.

Other activities expected to take place in the next 10 to 15 years on the Refuge and on surrounding lands between Interstates 8 and 10 and between U.S. Highways 95 and 85 include:

Energy Development. Southern California Edison has repeatedly proposed the addition of a second 500 kilovolt powerline (the Devers Paloverde #2) which would likely cross the northern portion of the Refuge, paralleling the existing Devers Paloverde #1 powerline. Southern California Edison is also proposing an additional 500 kilovolt powerline to parallel their existing 500 kilovolt powerline that parallels the Rio Grande Railroad and the Gila Valley. El Paso Natural Gas Company can be expected to maintain, refurbish and replace their existing oil and natural gas pipelines that parallel the Devers Paloverde #1 powerline and also run north/south near the Refuge's western boundary. The Department of Energy (Western Area Power Administration) powerline that parallels the Refuge's western boundary may be completely changed from wooden to steel support structures. Five of the support structures are on the Refuge. American Tower's 369-foot steel communication tower in the Livingston Hills may eventually be decommissioned and removed, along with the cement support building at its base. A large solar energy facility is proposed to be constructed on BLM-managed public lands north of the Refuge along the Vicksburg Road south of I-10, and another is expected to be constructed on private land southeast of the Refuge in the Hyder Valley near the Palomas Mountains. A wind farm consisting of large windmills and associated electrical collection facilities has been considered in the Little Horn Mountains east of the Refuge. Other solar and wind energy facilities may also be considered.

Mining. The small Verdstone open-pit gold mine in the Little Horn Mountains approximately four miles east of the Refuge boundary may be reactivated depending on gold prices. If gold and silver prices continue to rise, there may be an increase in mining activity including the establishment of new mines on public lands not withdrawn from mineral entry.

Road Maintenance and Improvement. Efforts to maintain the Refuge's roads can be expected to continue, including efforts by Yuma and La Paz County to grade and potentially regravel those roads that are county roads (Castle Dome, King Valley, and Vicksburg Roads). The Service would continue to maintain and grade the Palm Canyon, MST&T, and Crystal Hill/Blevins Roads, while keeping the remaining Refuge roads passable. The Arizona Department of Transportation (ADOT) has begun the process of expanding U.S. Highway 95 to four lanes between mileposts 42 and 70, and potentially fencing one or both sides of the highway, which could impede the movement of bighorn sheep and other wildlife.. ADOT is currently in the process of expanding U.S. Highway 85 from two to four lanes between Interstates 8 and 10.

Actions on Private Lands or by Private Individuals. The owner of the Castle Dome Mine Museum, which is on a 23.9 acre private inholding within the Refuge, has approached Yuma County about potentially paving the existing gravel Castle Dome Road. A home is proposed to be constructed on a 60-acre private inholding near the Colorado Mine in the foothills of the Castle Dome Mountains.

The future activities on the Refuge and in areas near the Refuge will underscore the importance of the Refuge as lands set aside primarily as wildlife habitat, where little human development has taken or is expected to take place.

5.2 Alternative B – Proposed Action – Conduct Limited Removal of Mountain Lions

Alternative B, the Proposed Action Alternative, would involve the limited removal of mountain lions through lethal control or translocation. The thresholds for mountain lions to be removed or considered "offending" are discussed in Section 3.2; an offending mountain lion is one that has killed two or more desert bighorn sheep within a six-month period. The Proposed Action Alternative has the potential to impact biological resources, considered in Section 5.2.1, 5.2.2, and 5.2.3, and social factors considered in Sections 5.2.4, 5.2.5, and 5.2.6.

5.2.1 Impact on Mountain Lion Populations. Under this alternative, mountain lions that regularly kill desert bighorn sheep on the Refuge could be translocated or lethally removed; therefore, this alternative would have direct impacts on individual mountain lions. Alternative B would be less humane to mountain lions than Alternative A because of these direct impacts. However, Alternative B would be more humane to mountain lions than Alternative C because removal of mountain lions would be dependent on them achieving offending status. Alternative B would create consistent management policies for mountain lions in occupied bighorn sheep habitat both on the Refuge and on adjacent lands (i.e., BLM, YPG) off the Refuge. The removal of a few mountain lions per year from the Refuge would be consistent with the AGFD guidelines for the management of mountain lions in Arizona.

As of this writing, at least three adult lions and two kittens are known to be using the Refuge (from photographs at water sources in 2009: a male, a female, and two kittens in the Kofa Mountains and a male [possibly KM02] in the Castle Dome Mountains.) DNA analysis of scat suggests that more mountain lions may be present in both the Kofa and Castle Dome mountains, although the exact number and their current status is unknown. It is expected that mountain lions would periodically visit and reoccupy the Refuge from adjacent mountain ranges. The impacts of removals to the mountain lion population will depend on how many offending lions are removed, and to some extend upon sex of lions removed. A mountain lion population in Wyoming recovered from a 50% reduction in numbers (generated by heavy harvesting) in three years, during which light harvesting (six to eight mountain lions per season) was still permitted (Anderson and Lindzey, 2005). Anderson and Lindzey (2005) also indicated that removal of males, the cohort most easily replaced by immigration, and subadult females, which can be quickly replaced by female young produced in the population, will have less impact on the population than removal of adult females, which are more difficult to replace. Additionally, the removal of only offending lions would mean that non-offending lions would continue to occupy and defend their home range territories on and off of the refuge, thus reducing the use and occupation of those areas by lions that may be more likely to reach offending status.

Logan et al. (1996) determined the rate of increase in a study of New Mexico mountain lion populations varied from 8-11% in an unhunted, uncontrolled population to 21-28% in a mountain lion population after a period where harvest and control was simulated by removing half of the mountain lions from the study area. They concluded that rates of increase in mountain lion populations are density dependent; as a population declines in relation to carrying capacity, the rate of increase becomes greater. This is a natural mechanism of wildlife populations that serves to protect species by enhancing the ability of populations to recover from declines. Logan et al. (1996) suggested that, for a lion population to remain at or near maximum carrying capacity, no more than 11% of the adults should be harvested annually. It also suggested that, for a

population managed for control, the harvest level might need to exceed 28% per year to cause the population to decline substantially. It appears that a viable population can be maintained at about 50% of carrying capacity with harvest levels that range from 21% to 28%.. Mountain lions that prey primarily on mule deer or other prey would remain on the Refuge and the surrounding lands.

The male lions might leave the Refuge, or spend less time there, if all adult females were removed. The proposed removal of offending mountain lions under Alternative B is not expected to extirpate lions from the Refuge. The time consuming and difficult logistics of capturing and collaring mountain lions and following their movements to determine whether they are offending lions, or not, limits the number of animals that could be removed.

Translocations are stressful to animals and mortality from capture and handling is always a possibility, although techniques to reduce stress are employed. Mountain lions that survive the capture and translocation effort are still subject to intraspecific competition that may lead to direct mortality through fighting or indirect mortality from starvation. Translocated mountain lions may also disrupt the dynamics of the population into which they are introduced, possibly causing unintended mortality among mountain lions in the receiving population.

Translocations do not always work. Translocated lions have been known to return to their capture area, which would defeat the purpose of translocation. If a translocated lion returned to the Refuge and continued killing bighorn sheep, lethal removal would be the only practical option. Translocated lions are also likely to be killed by resident lions in the area to which they are translocated, or to die from indirect effects of intra-specific competition. In this sense translocations are less effective than lethal removal and may be less humane and more costly.

A study in New Mexico (Ruth et al. 1998) designed to determine the feasibility of translocating mountain lions as a tool to manage populations and problem individuals, moved 14 adult lions an average of 477 kilometers (km) (296 miles) from their home range. Upon introduction, the mountain lions moved from 3 to 494 kilometers (1.8 to 307 miles) from the release site. Two of the mountain lions returned the distance to their original home range. Nine of the 14 translocated mountain lions died during the study period, due to intraspecific aggression, injuries associated with prey capture, human causes, bacterial infection, or unknown causes. This study suggests that translocation should only be done to bolster populations elsewhere (vacant territories) with younger mountain lions; young mountain lions are not as likely to return to their capture site.

5.2.2 Impact on Bighorn Sheep Populations. Alternative B is the most likely alternative to meet the objectives presented under Section 1.5. The removal of mountain lions known to regularly kill desert bighorn sheep is the action most likely to result in an increase in the number of desert bighorn sheep since disease and nutritional concerns have not been found to be a significant cause of mortality to date (see Chapter 4 for a discussion of the causes of sheep mortality), and predation is currently the predominant mortality factor in collared bighorn ewes on the Refuge.

Removing offending lions should be beneficial to the bighorn sheep herd, depending on other factors limiting their population. Long-term lamb to ewe ratios determined during fall aerial

surveys when lambs are less than 12 months old have averaged about 20 lambs per 100 ewes. This low level of production requires extremely high adult ewe survival rates (>0.90) for population persistence (Bender and Weisenberger 2005, Bender 2006). Because recruitment is so low, bighorn sheep take a long time to increase their numbers and the longevity and productivity of ewes is vital to maintaining a population. Bighorn sheep have low intrinsic rates of population growth, which means their ability to recover rapidly from herd depletion is compromised relative to other species (Geist 1975). Thus, a rapid recovery of the bighorn herd should not be expected with the implementation of Alternative B, but rather a stoppage of the population decline and slow recovery. This was supported by the bighorn population modeling (Section 4.6.5 and Appendix D), which indicated that decreases in bighorn sheep populations can happen quickly and take decades to recover.

Predation by mountain lions can be a substantial source of mortality in some bighorn sheep populations (McKinney et al. 2006b, Kamler et al. 2002, Logan and Sweanor 2001, Hayes et al. 2000, Schaefer et al. 2000), and mountain lions appear to be the only predators that can cause significant mortality in bighorn sheep populations that occupy suitable habitat (Sawyer and Lindzey 2002). Research indicates individual lions may be responsible for the majority of predation in a given area, and adverse effects are most likely to occur in small isolated desert populations (Sawyer and Lindzey 2002). For example, there is considerable evidence that increased mountain lion predation during the 1980s sent Sierra Nevada bighorn herds toward extinction in California and given the social nature of bighorn sheep biology the herd has not recovered (Wehausen 1996). Festa-Bianchet et al. (2006) documented that switches to mountain lion predation as the limiting factor occurs surprisingly frequently in bighorn sheep populations, and that the onset of high predation episodes was unrelated to bighorn sheep density. In the Mazatzal Mountains of central Arizona, McKinney et al. (2006b) found that nutritional status and mountain lion predation during a drought influenced desert bighorn sheep population parameters and that short-term removal of mountain lions contributed to higher growth and productivity of the small, isolated population - even during periods of drought. The recent findings of McKinney et al. (2006a) support the idea that predation of desert bighorn sheep by mountain lions is independent of predator abundance, and thus may be more a function of learned behavior by individual predators. The population modeling exercise also suggested that mountain lions could have easily (and rapidly) caused the population decline observed on the Refuge (see Section 4.6.5 and Appendix D). Removing offending lions may allow the herd to increase to levels better able to sustain lion predation in the future and allow resumption of the bighorn sheep translocation program.

5.2.3 Impact on Non-Target Species. Impacts to nontarget species from efforts to capture, translocate, or lethally remove mountain lions are anticipated to be small. When foot snares are used to capture lions, they are equipped with a pan-tension device that excludes animals of lighter weight. Non-target animals might be captured in box traps, but can be easily released unharmed. Shooting is highly target specific and does not pose a risk to non-target animals when conducted by professional wildlife specialists trained in firearm use and trained to identify target and non-target species. Dogs used to track mountain lions do not pose a threat to non-target species because they are trained to trail only mountain lions.

Numbers of desert mule deer may increase on the Refuge and in the surrounding areas if the Proposed Action is implemented, subject to other factors that affect deer numbers.

5.2.4 Impact on Visual Resources and Recreation. Alternative B – the Proposed Action would have only minimal impacts on visual resources. Snares used for capturing lions are inconspicuous and set well away from heavily used public areas. It is unlikely that a visitor would encounter any of these devices, and they cannot be seen from a distance.

The proposed action is expected to lead to an increase in recreational opportunities for both hunters and wildlife watchers due to an anticipated expansion of the refuge desert bighorn sheep population. There may also be an increase in the number of hunting tags issued for mule deer. This could be expected to result in a positive economic impact to the local area from increased visitation to the Refuge by both non-consumptive wildlife viewers and hunters.

5.2.5 Impact to Wilderness. Alternative B would involve little use of motorized equipment in wilderness. Personnel involved in the placement of snares, radio-collaring of mountain lions, and lethal removal of offending lions would access portions of the Refuge away from the roads on foot. Translocation of mountain lions would likely involve the brief uses of a helicopter to transport tranquilized lions. Wilderness issues arise from wilderness values, of which both mountains lions and bighorn sheep are a part. Mountain lions are a native predator, albeit one that has not been historically common in the immediate region. Desert bighorn sheep are also native to the region and their preservation was the driving force behind establishment of the Refuge. Under the proposed alternative, the wilderness value of the Refuge could be diminished from the standpoint that a natural predation process is being limited and a component of wilderness is being removed. The wilderness value of the Refuge might also be increased by a rise in the population of desert bighorn sheep.

For wilderness areas within the System, the purposes of the Wilderness Act are considered to be "within and supplemental" to the purposes for the specific Refuge; i.e., the wilderness purposes are additional purposes for the Refuge and must be considered within the legal context of the applicable wilderness statutes. The preservation of wilderness values, which includes wildlife populations, is an important mandate that is considered in the management of the Refuge. Thus, wilderness designation does not preclude active management of resources, but it does require greater scrutiny of management activities such that wilderness character is preserved Preserving wilderness character is a primary criterion for judging the appropriateness of proposed refuge management activities in wilderness. Preserving wilderness character requires that we maintain both the tangible and intangible aspects of wilderness. Wilderness character increases as it approaches the highest measure of natural conditions and being untrammeled.

Service policy (610 FW 2.16) states that we conserve fish, wildlife, and plant resources and their habitats in wilderness in a manner consistent with the National Wildlife Refuge System Administration Act of 1966, the National Wildlife Refuge System Improvement Act of 1997, and refuge purposes, including Wilderness Act purposes. Fish, wildlife, plants and their habitat are essential and inseparable components of wilderness.

Service policy [610 FW 2.16B(1)] also states that we will not interfere with natural processes in wilderness unless necessary to accomplish refuge purposes, including Wilderness Act purposes. This includes the disruption of predator/prey relationships. Service policy (610 FW 2.20) specifically addresses predation control in Refuge wilderness areas and states:

"*Predation is an essential and integral process in the wilderness ecosystem. We will initiate actions intended to alter natural predator/prey relationships only when compelling evidence exists that the proposed action will correct or alleviate identified impacts on native fish, wildlife, plants, or their habitats and would be in compliance with section 2.16. We will direct control at the individual animal(s) causing the problem using the method least likely to adversely impact nontarget species and wilderness visitors. We will not manage predation solely to protect livestock, wilderness visitors, or other users.*"

Alternative B conforms to the policy because it is being proposed to reduce adverse impacts to the Refuge bighorn sheep herd. The continued presence of the herd is essential to meeting the purposes of the Refuge. The Service also proposes to target the individual animals causing the problem and there would be few, if any, potential adverse impacts to non-target species. See the MRGD for a more detailed description of these impacts (Appendix E).

5.2.6 Other Considerations. Implementing Alternative B, the Proposed Action, is most likely to meet the concerns of those individuals, agencies, and organizations that expressed a desire for prompt action on the part of the Service to address the bighorn sheep decline.

Alternative B also meets the needs of those who expressed concern that mountain lions on the Refuge might undo some of the efforts to date toward the conservation of bighorn sheep. Alternative B would be the most costly, however, of the three action alternatives, in the short term.

Under Alternative B, contract trappers could continue to be hired to work on the Refuge to trap and radio-collar mountain lions. The funding for these efforts, like those in the past, would come from both agency and private sources and would cost approximately $25,000 per year. Other expenses include GPS-equipped radio collars which cost approximately $5000 each, along with drugs to temporarily immobilize lions. Alternative B would also continue to support an additional position at the Refuge, a temporary biological technician.

5.2.7 Cumulative Impacts

5.2.7.1 Cumulative Impacts to Mountain Lions. Mountain lions throughout the state of Arizona for an approximately 50-year period were considered in this analysis. The AGFD estimates that there are currently 2,500 to 3,000 mountain lions in the state of Arizona. Since 1982, the year mandatory check-outs were established, mountain lion harvest has ranged from 193-384 lions per year, approximately 15% of which were taken by APHIS-WS wildlife specialists and private individuals to solve depredation issues (AGFD 2007b, AGFD 2008). The removal of these mountain lions has occurred while mountain lions apparently re-occupied and expanded their range in Arizona, including into the Refuge. Mountain lion hunting is not allowed on any of the nine National Wildlife Refuges in the state of Arizona, although it is allowed in all of the GMUs surrounding the Refuge. However, no sport hunter has ever reported harvesting a lion in any of these surrounding units.

In a regional setting, removal of offending lions will not adversely affect the statewide mountain lion population and is within the mountain lion population objectives set by the AGFD.

Mountain lion population densities were documented as high as 6.9 lions/100 mi^2 in the area surrounding Aravaipa Canyon and Klondyke, Arizona (Cunningham et al. 1995), and mountain lions are known to occupy every mountain range between the Refuge and central Arizona, including the Vulture, Harquahala, Harcuvar, Bighorn, Weaver, Date Creek, and Granite Wash Mountains. However, it is possible that the local Refuge population of lions could be reduced below a sustainable population, especially if females are removed. Mountain lions are solitary animals that may reoccupy vacated areas slowly (Logan et al. 1996). The proposed alternative is not intended to extirpate lions from the Refuge, if a sustainable population exists and persists, and past experience capturing lions on the Refuge has demonstrated that removing all lions would be extremely difficult, expensive, and unlikely. At this time, only one breeding female is known to be on the Refuge. If this female is removed it may take some time for another female to establish a territory on the Refuge, although another female is believed to be in the Castle Dome Mountains based on DNA collected from a mountain lion scat. Male mountain lions have large home ranges and disperse widely; if a male mountain lion is taken it would probably take less time for another male to replace a male that is removed. DNA from scat samples collected on and around the Refuge suggests that there are more male mountain lions than would be inferred from remote camera monitoring, and that the Refuge mountain lion population is not small, isolated, or unique. The Refuge mountain lion population was long considered transient and may become so again.

The AGFD is currently considering expanding its existing predation management plan for the area surrounding the Refuge to include additional units and stricter criteria in southwestern Arizona (R Thompson, pers. comm.). This could alter the cumulative impacts of Alternative B on the regional mountain lion population. However, as discussed in Section 5.2.1, mountain lion populations have been observed to recover from heavy harvest in three years. It is unlikely that even regionwide offending mountain lion removals would permanently impact the statewide mountain lion population.

The impacts of translocating mountain lions into a new area on the wildlife already present in that area would vary upon the location(s) selected and are outside the scope of this document.

5.2.7.2 Cumulative Impacts to Bighorn Sheep. Cumulative impacts to bighorn sheep in Arizona and New Mexico for the next 50 years were considered in this analysis. The Refuge bighorn sheep herd has been a source population for bighorn sheep translocations since 1957. From 1957 through 2006, 569 bighorn sheep were translocated from the Refuge to supplement populations in Arizona, New Mexico, Colorado, and Texas. After the decline noted in 2006, the translocation program was suspended indefinitely until the sheep population recovers to the translocation guidelines set out in the USDI 1997. This includes an effort to reestablish desert bighorn sheep in the San Andres Mountains on San Andres NWR in New Mexico, along with transplants in Arizona to the Mineral, Maricopa, Black, Superstition, Table Top, Sauceda, Harquahala, Bighorn, Gila Bend, Buckskin and Santa Catalina Mountains and the Buckeye Hills among other locations. The Refuge bighorn sheep have provided vital population boosts and genetic variety to bighorn sheep herds in Texas, New Mexico, Colorado, and Arizona. If Alternative B is implemented and the effort is sustained over time, the desert bighorn sheep population could be expected to recover, but this recovery may take as much as 50 years (see Section 4.6.5 and Appendix D), Once the sheep numbers have recovered, transplants can

continue, which would provide benefits to bighorn populations over the entire southwestern region.

5.2.7.3 Other Cumulative Impacts. Other cumulative impacts include the indirect impacts to mule deer numbers, recreation, and Wilderness described in Sections 5.2.3, 5.2.4, 5.2.5, and 5.2.6. The cumulative impacts of other activities expected to take place in the next 10 to 15 years on the Refuge and on surrounding lands between Interstates 8 and 10 and between U.S. Highways 95 and 85 include the mining, development of energy including the establishment of solar and wind farms, and the development on private land and by private individuals is the same as what is described for Alternative A in Section 5.1.7.

5.3 Alternative C – Indiscriminate Removal of Mountain Lions

Alternative C, the Indiscriminate Removal of Mountain Lions Alternative, would involve removal of mountain lions through lethal control or translocation. This alternative is somewhat similar to Alternative B, the Proposed Action, with some differences. Alternative C, if implemented, has the potential to impact biological resources, considered in Sections 5.3.1, 5.3.2, and 5.3.3, and social factors considered in Sections 5.3.4, 5.3.5, and 5.3.6.

5.3.1 Impacts on Mountain Lion Populations. Because mountain lions would be removed indiscriminately until the mountain lion population is reduced enough to effect a change in the bighorn population, this alternative could possibly result in the removal of more mountain lions overall because removing non-offending mountain lions may not produce the desired results. Ernest et al.'s (2002) modeling indicated that landscape-level removal resulted in more removals of mountain lions that did not prey on bighorn sheep than selective removal of offending lions. Because of this possibility, Alternative C is the least humane to mountain lions of the three Alternatives, although lethal and non-lethal of removal of lions would still adhere to AVMA guidelines to minimize the suffering of individual animals.

Indiscriminate removals would be the most effective and cost-efficient way to remove mountain lions; however, indiscriminate removals would remove mountain lions that do not necessarily prey on bighorn sheep, resulting in additional mountain lions likely being removed, and their possible extirpation from the Refuge. Stoner et al (2006) indicated that harvests exceeding 40% of the nonjuvenile population for more than four years can not only reduce density of mountain lions but may also promote or maintain a demographic structure that is younger, less productive, and socially unstable. Additionally, this alternative would be less effective than Alternative B in gathering information to be used for mountain lion management, which in turn supports adaptive management of both species

5.3.2 Impact on Bighorn Sheep Populations. Impacts to bighorn sheep populations would be similar to those mentioned under Alternative B, or possibly more beneficial. Ernest et al. (2002) found that as a general rule, indiscriminate removals were equal or superior to selective removals in terms of reducing bighorn sheep predation mortality. Thus, the removal of mountain lions under this alternative would likely have the same or slightly better effect on the bighorn sheep population than under Alternative B.

5.3.3 Impact on Non-target Species. Impacts to non-target species would be similar to those discussed under Alternative B.

5.3.4 Impact on Visual Resources and Recreation. Impacts to visual resources and recreation would be similar to those discussed under Alternative B.

5.3.5 Impact to Wilderness. Impacts to Wilderness would be similar to those discussed under Alternative B. See the MRDG for a more detailed description of these impacts (Appendix E).

5.3.6 Other Considerations. Implementing Alternative C in part meets the concerns of those individuals, agencies, and organizations that expressed a desire for prompt action on the part of the Service to address the bighorn sheep decline. Alternative C meets the needs of those individuals, agencies, and organizations that requested the removal of as many mountain lions as possible from the Refuge. Alternative C does not meet the needs of those who requested that the Service limit or avoid any action that causes the death of animals. Alternative C would be the second most costly of the three action alternatives in the short term, with Alternative B being the most expensive.

Under Alternative C, contract trappers would continue to be hired to work on the Refuge to trap and mountain lions. The funding for these efforts, like those in the past, would come from both agency and private sources and would cost approximately $25,000 per year. As in Alternative B, drugs would be needed to temporarily immobilize lions if they were translocated, but no funds would be needed for radio-collars. Alternative C would also continue to support an additional position at the Refuge, a temporary biological technician.

5.3.7 Cumulative Impacts Cumulative impacts to mountain lions and bighorn sheep would be similar to those discussed under Alternative B, the proposed action. The cumulative impacts of other activities expected to occur on or near the Refuge would be the same as described for Alternative A in Section 5.1.7.

5.4 Unavoidable Adverse Impacts

The selection of any alternative would have no unavoidable adverse direct or indirect impact on the environmental parameters evaluated in this EA.

5.5 Irreversible and Irretrievable Commitments of Resources

The management actions identified in this document will require a commitment of funds that would then be unavailable for use on any other Service projects. At some point, commitment of funds to these projects would be irreversible, and once used, these funds would be irretrievable. Non-renewable or non-recyclable resources committed to implement the proposed action, such as fuel, would also represent irreversible and irretrievable commitments of resources, but would be very minor in scope and not appreciably different under any of the alternatives.

5.6 Indian Trust Assets

No Indian Trust Assets have been identified on the Refuge (Clark 2004). There are no reservations or ceded lands present. Because resources are not believed to be present, no impacts are anticipated to result from implementation of any alternative described in the EA.

5.7 Environmental Justice

Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority and Low-Income Populations; February 11, 1994) was designed to focus the attention of Federal Agencies on the environmental and human health conditions of minority and low-income populations, with the goal of achieving environmental protection for all communities. The order directed federal agencies to develop environmental justice strategies to aid in identifying and addressing disproportionately high and adverse human health and environmental effects of their programs, policies, and activities on minority and low-income populations. The order is intended to promote nondiscrimination in federal programs substantially affecting human health and the environment, and to provide minority and low income communities with access to public information and opportunities for participation in matters related to human health and the environment.

The development of this document and none of the alternatives described in this EA have or will disproportionately place any adverse environmental, economic, social, or health impacts on minority and low income populations. Implementation of the proposed action is anticipated to benefit the environment and all people..

5.8 Summary and Conclusions

Three alternatives were evaluated for potential impacts to environmental resources. Alternative A - the No Action Alternative, Alternative B – Proposed Action, and Alternative C – Indiscriminate Removal of Mountain Lions.

Alternative A – would be the least effective at meeting the Refuge's objectives related to bighorn sheep. Alternative A would be the least costly alternative in the short term since no mountain lions would be removed from the Refuge. It may also be the most costly in the long term, since desert bighorn sheep numbers may be expected to continue to decline, necessitating more costly management measures in the future to increase their numbers. Alternative A is considered the most humane alternative to mountain lions since no mountain lions on the Refuge would be subject to the stresses and anxiety that would be involved in translocation or removal.

Alternative B – is the alternative that is the most likely to be effective in increasing numbers of desert bighorn sheep while maintaining mountain lions that do not regularly kill bighorn sheep on the Refuge. Alternative B would be the most costly alternative in the short term since it is logistically difficult and time-consuming to capture, collar, monitor, and then remove offending lions. Alternative B allows mountain lions that do not regularly kill desert bighorn sheep to remain on the Refuge. This alternative also provides the most information concerning mountain lions including their movements and diet. Alternative B is expected to be less costly in the long term than Alternative A.

Alternative C – would be intermediate in cost between Alternatives A and B, but would result in the removal of mountain lions that do not regularly kill desert bighorn sheep. This alternative would provide little new information concerning mountain lion movements and diet, and is considered the least humane to mountain lions of the three alternatives.

This EA is intended to support adaptive management and implementation of additional management approaches as more information is gathered.

6.0 COMPLIANCE, CONSULTATION AND COORDINATION

This section provides information regarding consultation and coordination that has occurred with other federal and state agencies, interested stakeholders, and the public; list of preparers; and references used in preparation of this EA.

6.1 Authority and Compliance

The Service cooperates with land and wildlife management agencies to resolve management problems in compliance with applicable federal, state, and local laws.

Based on agency responsibilities, missions, and legislative mandates, the Service is the "lead agency" and "decision maker" for this EA and therefore responsible for the EA's scope and content. As cooperating agencies, the AGFD, APHIS-WS, and BLM have provided input on this EA and will provide advice and recommendations to the Service on when, where, and how mountain lion management could be conducted.

6.1.1 Authority of Federal and State Agencies

USDI - U.S. Fish and Wildlife Service. The Service, under the National Wildlife Refuge Administration Act of 1966 (as amended) and the National Wildlife Refuge Improvement Act of 1997, administers lands and waters in the National Wildlife Refuge System for the conservation, management, and restoration of fish, wildlife and plant resources and their habitats.

USDI - Bureau of Land Management – The Bureau of Land Management, Yuma Field Office, manages approximately 1.1 million acres of public land, including some of the lands surrounding the Refuge, under the Federal Land Policy and Administration Act of 1976. BLM has the responsibility to manage the resources on public lands for multiple uses including livestock grazing, timber production, recreation, and wildlife habitat, while recognizing the State's authority to manage wildlife populations. These uses are outlined in Resource Management Plans. BLM is an integral part of the overall plan to reduce mountain lion predation on desert bighorn sheep because the public lands they manage are adjacent to the Refuge.

Arizona Game and Fish Department. AGFD, acting under authority of the Arizona Game and Fish Commission, and Arizona Revised Statutes Title 17, has trust responsibilities for the protection and management of wildlife in the state.

USDA -APHIS-Wildlife Services. The primary statutory authorities for the APHIS-WS program are the Act of March 2, 1931, as amended in the Fiscal Year 2001 Agriculture Appropriations Bill, and the Act of December 22, 1987 which authorize and direct APHIS-WS to manage damage caused by wildlife, in cooperation with other agencies.

6.1.2 Compliance with Federal Laws

The following federal laws and Service policies are relevant to the actions considered in this EA; keys laws are described first, followed by a list of all applicable laws considered.

National Environmental Policy Act of 1969 (NEPA). **(42 USC Section 4231, et seq.,)**; the President's Council on Environmental Quality (CEQ) Regulations, 40 Code of Federal Regulations (CFR) Section 1500 - 1508; Department of the Interior's Departmental Manual for NEPA compliance, Fish and Wildlife Service (516 DM 6). Individual actions by any federal agency implementing conservation or recovery actions identified in conservation or recovery plans may be subject to NEPA.

National Wildlife Refuge System Administration Act of 1966 (16 U.S.C § 668dd-668ee). This Act, derived from sections 4 and 5 of Public Law 89-669, consolidated game ranges, wildlife ranges, wildlife management areas, waterfowl production areas, and wildlife Refuges into a single National Wildlife Refuge System. It also established the "compatibility standard" for allowing uses on a refuge only when such uses do not materially interfere with or detract from the purpose of the refuge.

National Wildlife Refuge System Improvement Act of 1997 (H.R. 1420, 105th Congress). This law amended the National Wildlife Refuge System Administration Act of 1966 and provided comprehensive direction with regard to how National Wildlife Refuges are to be administered. There are several key themes of the legislation including management of National Wildlife Refuges as a system to fulfill the stated mission. The law also created a hierarchy of activities, putting wildlife first, priority public uses next, and then other uses. The law further mandated that all uses of a Refuge be compatible with the System mission and the unit's purpose. Comprehensive conservation planning was also mandated for all Refuge units.

Wilderness Act of 1964 (16 U.S.C. 1131-1136, 78 Stat. 890) -- Public Law 88-577. This law defined allowable and prohibited uses of wilderness, and directed the Secretary of the Interior to review every roadless area of five thousand contiguous acres or more within the national wildlife refuges and game ranges, and report his recommendation as to the suitability or nonsuitability of each such area or island for preservation as wilderness.

Arizona Desert Wilderness Act of 1990. Public Law 101-628. This law designated portions of the Kofa National Wildlife Refuge as part of the National Wilderness Preservation System.

Other Applicable Laws Considered:

- Administrative Procedure Act (1966; 5 U.S.C. §551-559, 701-706 and 801-808, as amended)
- American Indian Religious Freedom Act (1978)

- Antiquities Act of 1906 (16 U.S.C. §431-433)
- Archaeological and Historic Preservation Act (1974)
- Archaeological Resources Protection Act of 1979, as amended (16 U.S.C. §470aa-470mm)
- Appropriate Uses Policy (2006) 603 FW1
- Bald and Golden Eagles Protection of 1940 (16 U.S.C. §668-668d; 54 Statute 250)
- Biological Integrity, Diversity, and Environmental Health (2001) 601 FW 3
- Clean Air Act (1970; 42 U.S.C. 7401 et seq.), as amended
- Clean Water Act (1977); Federal Water Pollution Control Act
- Compatibility Policy (2000) 603 FW 2
- Convention Between the United States of America and the Mexican States for the Protection of Migratory Birds and Game Mammals, 1936 (50 Statute 1311)
- Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere, 1940 (56 Statute 1354).
- Endangered Species Act of 1973, as amended
- Environmental Education Act of 1990 (20 U.S.C. §5501-5510)
- Executive Order 11514; Protection and Enhancement of Environmental Quality (1970)
- Executive Order 11644; Use of off-road vehicles on the public lands (1972)
- Executive Order 11989; Off-Road Vehicles on Public Lands (1977)
- Executive Order 12996; Management and General Public Use of the National Wildlife Refuge System (1996)
- Executive Order 13007; Indian Sacred Sites (1996)
- Executive Order 13112; Invasive Species (1999)
- Executive Order 13186; Responsibilities of Federal agencies to protect migratory birds (2001)
- Executive Order 13443; Facilitation of Hunting Heritage and Wildlife Conservation (2007)
- Federal Aid in Wildlife Restoration Act (1937; 16 U.S.C. §669-669i), as amended
- Federal Environmental Pesticide Control Act of 1972 (7 USC §136-136y), as amended
- Federal Noxious Weed Act (1990)
- Fish and Wildlife Act of 1956 (16 U.S.C. §742a-742j, not including 742 d-l), as amended
- Fish and Wildlife Conservation Act of 1980 ("Nongame Act")(16 U.S.C. §2901-2911), as amended
- Fish and Wildlife Coordination Act (1934), as amended
- Fish and Wildlife Improvement Act of 1978 (16 U.S.C. §7421; 92 Stat. 3110), as amended
- Freedom of Information Act (1966; 5 U.S.C. §552)
- Lacey Act of 1900 (16 U.S.C. §701), as amended Land and Water Conservation Fund Act (1965)
- Migratory Bird Conservation Act (1929; 16 U.S.C. §715-715d, 715e, 715f-715r), as amended Migratory Bird Treaty Act of 1918 (16 U.S.C. §703-712), as amended
- Migratory Bird Hunting and Conservation Stamp Act (1934; 16 U.S.C. §718-718j), as amended
- National Historic Preservation Act of 1966 (16 U.S.C. §470-470b, 470c-470n), as amended:

- National Wilderness Preservation System (1964)
- Native American Graves Protection and Repatriation Act (1990)
- Protection Act (1922; 16 U.S.C. §594)
- Refuge Recreation Act of 1962 (16 U.S.C. §460k-460k-4), as amended
- Refuge Revenue Sharing Act of 1935 (16 U.S.C. §715s), as amended
- Refuge Trespass Act of 1948 (18 U.S.C. §41)

6.2 Agencies and Organizations Consulted

USDA-APHIS-Wildlife Services
Thomas C. Hall, Operational Support Staff and Environmental Management Coordinator
US Army –Yuma Proving Ground
Jason C. Gibbons, Wildlife Biologist
Arizona Game and Fish Department
Bob Henry, Region IV Game Specialist
John Hervert, Region IV Wildlife Program Manager
Russ Engel, Region IV Fisheries Program Manager (previously Habitat Program Manager)
Ron Thompson, Big Game Habitat and Large Carnivore Specialist
Troy Smith, Region IV Habitat Program Manager
Pat Barber, Region IV Supervisor
Bureau of Land Management, Yuma Field Office
Winfred Wong, Wildlife Biologist
J. Todd Shoafe, Yuma Field Office Manager
Karen Reichhardt, Team Lead, Natural Resources Specialist
US Fish and Wildlife Service – Region 2, Albuquerque
Mitch Ellis, Project Leader, Southwest Arizona NWR Complex
Thomas Harvey, Refuge Supervisor – Arizona and New Mexico
Kathy Granillo, Wildlife Biologist
Rob Campellone, Chief, Division of Planning
Carol Torrez, NEPA Coordinator, Division of Planning
Grant Harris, Ph.D., Conservation Goals Coordinator
Justin Tade, Field Solicitor
US Fish and Wildlife Service – Washington Office – Arlington, Virginia
Andy Loranger – Division Chief, Natural Resources and Conservation Planning
Greg Siekanic – Chief of Refuges

6.3 Technical Preparers

Susanna Henry, Kofa NWR Refuge Manager, USFWS
Lindsay Smythe, Kofa NWR Wildlife Biologist, USFWS

6.4 Comment and Review Period

This EA has been published and is available for review to those agencies and individuals listed in Appendices B and C, as well as all of the individuals, agencies, and organizations that provided comments during the scoping period. Additional copies of this EA are available upon request. Inquiries should be directed to Kofa National Wildlife Refuge, 9300 E 28th St., Yuma, AZ 85365; 928-783-7861.

6.5 List of Acronyms

AGFD	Arizona Game and Fish Department
APHIS	Animal and Plant Health Inspection Service (USDA Agency)
AVMA	American Veterinary Medical Association
BLM	Bureau of Land Management
CCP	Comprehensive Conservation Plan
CFR	Code of Federal Regulations
EA	Environmental Assessment
FWS	U.S. Fish and Wildlife Service
GPS	Global Positioning System
MRDG	Minimum Requirements Decision Guide
NEPA	National Environmental Policy Act
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
VHF	Very high frequency
WS	Wildlife Services

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Appendix A - Species of Special Concern

The Refuge has 11 species of special concern. One of these species is a federally listed endangered species that is rarely present on the refuge during migration, the Southwestern Willow Flycatcher. It also has ten other species considered state sensitive. None of these species is expected to be impacted by any Alternative.

Table A1. Species of Special Concern potentially on Kofa NWR (AGFD 2008 - Heritage GIS Database @ http://www.azgfd.gov/w_c/edits/hdms_abstracts.shtml, *Last visited 12/17/2008*)

Scientific Name	Common Name	ESA Rank	State Rank	Status
BIRDS				
Egretta thula	Snowy Egret	-	WSC	Mfs
Falco peregrinus anatum	American Peregrine Falcon	-	WSC	Mfws
MAMMALS				
Euderma maculatum	Spotted Bat	-	WSC	U
Lasiurus blossevillii	Western Red Bat	-	WSC	Mfs
Lasiurus xanthinus	Western Yellow Bat	-	WSC	R
Macrotus californicus	California Leaf-nosed Bat	-	WSC	R
REPTILES				
*Gopherus agassizi (*Sonoran pop.*)*	Sonoran Desert Tortoise	-	WSC	R
PLANTS				
Mammillaria viridiflora	Varied Fishhook Cactus	-	SR	R??
Opuntia echinocarpa	Straw-top Cholla	-	SR	R??
Washingtonia filfera	California Fan Palm	-	SR	R??

State Rank – WSC=Wildlife of Special Concern, SR=Salvage Restricted – Collection only with permit
Status – M=Migrant (seasonal: f (fall), w (winter), s (spring)), R=Resident, U=Unknown (no records on Kofa, but possible)

Appendix B - Scoping Comments

On April 23, 2008, the Service announced its intent to prepare this Environmental Assessment exploring possible alternatives for the management of mountain lions and their impacts to desert bighorn sheep on the Refuge. A 30-day scoping period running April 24 to May 24, 2008 was established under that notice. The Service provided a news release to the media and sent out 4,007 letters and emails to potential interested parties announcing the initial scoping period for development of a lion management EA. In response to requests from the public for additional time to identify issues they would like addressed in the planning process, the Service extended the public scoping period an additional 30 days, to June 23, 2008.

During this scoping period the Service received 122 response letters or emails with comments that were considered as part of this analysis. The following agencies, organization, and individuals provided scoping comments:

Agencies

Arizona Game and Fish Department
Arizona State Parks
Laguna Natural Resource Conservation District
Yuma Natural Resource Conservation District
International Boundary and Water Commission
Town of Buckeye
U.S. Department of Agriculture – APHIS, Wildlife Services
U.S. Department of the Interior – Bureau of Land Management
Yuma County Board of Supervisors

Organizations

Animal Protection Institute
Animal Welfare Institute and Animal Defense League of Arizona
Arizona Antelope Foundation
Arizona Deer Association
Arizona Desert Bighorn Sheep Society
Arizona Sportsmen for Wildlife
Arizona Wildlife Federation
Defenders of Wildlife
Foundation for North American Wild Sheep – California Chapter
The Cougar Fund
The Humane Society of the United States
Public Employees for Environmental Responsibility – Southwest (PEER)
Safari Club International/Safari Club International Foundation
Sierra Club – Grand Canyon Chapter
Wild Sheep Foundation
Yuma Audubon Society (2 letters)
Yuma Valley Rod and Gun Club

Individuals

Warren Adams
Lynn Ashby
Larry Audsley
Janet E. Blevins
Bailey
Gary D. Barcom
David Barnes
Kim Bauer
Dave Berry
Bettina Bickel
Barbara Bockman
Gerald R. Bouck
Carl Brashears
Michael Breslow, M.D.
Tom Britt
Nuntanit Bumrungsap
Catherine Rick Carosone
Richard Caudill
Doris Cellarius
Gary Christensen
Steve Clark
Collins L. Cochran
David Colvin
John F. Colvin, Jr. (2 letters)
Mark Coryell
Patty Danley
Mike Daily
Rudy Dankwort
Lou Ann Denison
Brian Dolan
A. Donnici
Debora Durant
Bob Eck
George Elledge
Bea Elliott
Kevin Emmerich
Greg Ferguson
C.F. Gansberg, D.V.M.
Rich Glinski
Larry Heathington
Dick Henry
Mike Hirsch
Melissa Hughes
Lisa Hunt
Stewart A. Jackson, Ph.D.
Bruce H. Johnson
Ron Kearns (2 letters)
David Kennedy
Emily Kenny
Don Kleck
Colette Klinkenberg
Nancy Kroening
Lisa Kyriacos
Patricia Lambert
Rev. Davidson T. Landers
Mike Laughlin
James Loaris
Kim Maddox
Ron Marks
Mary Martin, Ph.D.
Clint Robert Matkovich
Alan McGee
David McKee
Kaitlyn McKee
Pam Nelson
Nancy Newkirk
Doug Newton
Jean and Franklin Olmsted
Brooks Pangburn
Sandy Peterson
Paul Pietrocarlo
Cheri Pillsbury
Steve Pollack
Bonnie Poulos
S. Raftery
Debra Raymond
Paul Roetto
B. Sahcua
Bruce R. Schoeneweis
Justin Schmidt
Harley G. Shaw
Roger Sherman
Sue W. Shimer
Carl Shores
William Smith
Glenn D. Sosebee
Gregory Stainton
Doug Stancill
David Strauch
Halina Szyposzynski
William C. Thornton
Gina Torgersen
Jim Unmacht
Angelina Valles
Dwight Van Brunt
Rich Veit
Dr. Elizabeth Wallace
Devan Wastchak
James T. White
Mary Williams
Lloyd and Patrick Wundrock
Mark Zachary

Approximately 42% of the scoping comments received (52) expressed opinions in favor of Alternative B – the Proposed Action Alternative, while approximately half (61) expressed opinions in favor of Alternative A – the No Action Alternative. Eight of the comments were neutral or general in nature. Many comments requested that information be included in the EA, including the long-term history of desert bighorn sheep on the Refuge, the methods of assessing the numbers of desert bighorn sheep and mountain lions, and information on lion predation and its effect on bighorn sheep in other areas. Some letters requested that the Service establish clear bighorn population guidelines detailing when lions would be removed or removals curtailed. Several mentioned that they would like to see the document include the impacts of water catchment construction on the bighorn sheep, mountain lions, and other wildlife species on the Refuge. Several commenters asked about the effects of drought on desert bighorn sheep. Concerns were expressed for the Refuge's mule deer population, and how it might be impacted by mountain lion predation. One commenter asked for a description of the biology of mountain lions and desert bighorn sheep and a detailed description of the relationship between climate and predator/prey dynamics. Another individual asked if mountain lions only kill what they can consume. Questions were expressed including how an animal can be shown to have been killed by a collared lion rather than scavenged. Several writers requested that the Service consider the ecosystem as a whole and provide a reasonable range of alternatives. A few letters requested that the Service include a minimum tool analysis with the EA. One individual asked the Service to be open-minded. Arizona State Parks requested that the Service take into account cultural resources in the EA.

Several of the comments that generally appeared to favor Alternative A, the no action alternative, requested that the Refuge not allow mountain lion hunting, or hunting of any species. One commenter expressed concern about the cost of capturing and placing collars on mountain lions and asked if the funds should it be spent on additional water sites instead. A few commenters likened the removal of offending lions from the Refuge to aerial wolf hunts or seal hunts in Canada and asked that "nature take its course." One organization stated "the practice of killing radio-collared mountain lions is flawed. Collared mountain lions are much more valuable to improving our understanding of their ecology and dynamics with bighorn alive than dead." Another organization asked for more empirical evidence describing how it is known that mountain lion predation is the cause of the desert bighorn sheep decline. Several individuals suggested that the Refuge be closed to all vehicles. A few writers suggested relocation of offending mountain lions, and one writer suggested relocating offending mountain lions to places where there is an overpopulation of deer. Several individuals and organizations asked the Service to consider no removal of mountain lions by agencies or hunters. Other writers asked that all desert bighorn sheep hunting be suspended. One writer asked the Service to use experienced observers and navigators during aerial bighorn sheep surveys.

Comments that generally appeared to favor Alternative B, the proposed action, requested that the Service go ahead with efforts to collar, monitor, and remove offending lions. Some commenters asked the Service to make a special effort to capture and remove a specific breeding female lion known to use the Refuge. Several writers asked that the Service emphasize that bighorn sheep and mountain lions are both non-endangered and non-migratory and that the formerly recognized Yuma puma (*Puma concolor browni*) does not really exist as a genetically unique subspecies. Several suggested opening the Refuge to lion hunting. Some writers suggested removing lions

even before the EA is completed. Others pointed out the long history of desert bighorn sheep conservation on the Refuge and asked the Service to act quickly before the sheep population dwindled to nothing, wasting all of the effort the Service has done to date for sheep. Several provided comments stating that the Service should not allow the Wilderness status of the majority of the Refuge to inhibit the implementation of lion management strategies. Several individuals stated that mountain lions need to be removed from the Refuge just like they were in GMU 22 (in central Arizona). Others pointed out that the expansion of a breeding population of lions into the Refuge is an indicator that mountain lion populations in the surrounding areas of southwestern Arizona are doing well. Several commenters mentioned that there has been considerable urbanization in Arizona and the pressures put on wildlife could be making problems for bighorn sheep worse. Some suggested removing all but one mating pair of lions or asked the Service to remove all lions. One writer stated "I hunted Kofa for sheep in 2007 and it took me 20 days to find my ram; there was lots of lion sign and very few sheep."

The broad range of comments received was considered in the writing of the draft EA. Information on several specific issues and alternatives was provided in the EA as a result of scoping comments. It is believed that this has helped to create a document that more completely explains the science, logic, and management emphasis driving the decision-making process.

Appendix C - Comments on the Draft Environmental Assessment and Service Responses

On August 4, 2009, the Service announced the availability in the *Federal Register* of the *Draft EA for Limiting Mountain Lion Predation on Desert Bighorn Sheep on the Kofa National Wildlife Refuge*. A 60-day comment period took place from August 4 through October 2. A copy of the Draft EA was available for downloading on the Refuge website at: www.fws.gov/southwest/refuges/arizona/kofa. In addition, email messages and letters were sent on August 4th to all individuals, agencies, and organizations that provided comments during the scoping period along with additional individuals, organizations, and agencies that have expressed an interest in Service planning at the Refuge.

On the afternoon of September 9, 2009, Service representatives met with representatives of six environmental organizations and the media in Tucson Arizona in an informal informational session. On September 16, the Service, BLM, AGFD, and APHIS-WS held a public information meeting at the Pivot Point Conference Center, 220 N. Madison Avenue, in Yuma, Arizona from 6:30 until 9:00 p.m. The meeting began with a 30-minute informational presentation followed by a 45-minute questions and answers session, and concluded with interested individuals asking questions and receiving information from agency personnel stationed at four tables around the perimeter of the room. The four tables had the following subject areas: 1) Refuge policy, planning, and management, 2) bighorn sheep conservation, 3) mountain lion life history and recent studies, and 4) the EA alternatives. Sixty members of the public attended the meeting. Participants were encouraged to provide written comments on the draft EA during the meeting on provided comment sheets, or emails or letters afterwards; no verbal comments were accepted.

During the Draft EA comment period, 219 response letters, informational meeting comment sheets, or emails were received and all were considered during the preparation of the final EA. The following seven agencies, 19 organizations, and 194 individuals provided comments on the draft EA:

Agencies

Arizona Game and Fish Department
California Department of Fish and Game – Blythe, California
International Boundary and Water Commission – United States and Mexico
Laguna Natural Resource Conservation District
State of New Mexico – Department of Game and Fish
Western Association of Fish and Wildlife Agencies (represents 21 agencies)
Yuma Natural Resource Conservation District

Organizations

Animal Defense League of Arizona
Animal Welfare Institute
Arizona Desert Bighorn Sheep Society, Inc.
Arizona Elk Society
Arizona Wildlife Federation

Center for Biological Diversity
Defenders of Wildlife
Desert Bighorn Council
Public Employees for Environmental Responsibility - Southwest
Safari Club International and Safari Club International Foundation
Sierra Club – Borderlands Campaign – Dan Millis
Sierra Club – Grand Canyon Chapter
Southwest Bowhunters
The Humane Society of the United States
U.S. Sportsmen's Alliance
Wild Sheep Foundation
Yuma Audubon Society
Yuma County Board of Supervisors – Greg Ferguson
Yuma Valley Rod and Gun Club

Individuals

Anonymous
Warren A. Adams
Ken Alexander
Jim Ammons
Michael Anderson
Patricia Armstrong
Larry Audsley
Barbra Barnes
Kim Bauer
William H. Barbee
John Barber
Gary Barcom
Donald G. Begalke
Bill Berlat
Lowell Berry
Fred Bianchi
Blaine Bickford
Michael Bieda
Sharon Biggs
Rikkie Boyd
Jeff Brewer
Tom Britt
Cynthia W. Buness
Douglas Burt
Tom Cadden
Tony Campbell
Chris Carlon
Rick Carosone
Randy A. Cherington
Dave Childress
Sheryl Christenson
John Clemons
Anne Coe
Michael Colbert
John Colvin
Brad Copper
Timothy S. Crowder
Randall Cuberly
Lucas Currell
Mike Daily
Kenneth R. Davis
Joe Del Re
Paul G. Denney III
Jim deVos
Robert Donaldson
Leslie Dornfeld, AICP
Jill Dredge
Darrell Driscoll
Pete Dufek
Jake Dunn
Debora Durant
Paul Durbin
Rachel Dzierzek
Roy Emrick
Jack R. Ferrell, Ph.D.
Andy Foster
Professor Paul Friesema
Cameron Frieh
Jon Fugate
Brad Gatlin
Jerry Gauthier
Brian R. George
Ronald Gissendaner
Shareen and Joseph Goodroad
Doug Goosey
Mark Grenard
Martin Gromulat, Esq.
Richard Guyette
N.H. P.S. Hannahan
David A. Harbster
Kevin Harris
Peter D. Hattasch Havns
Bart Haynes
Glen P. Henrick
David Hofeling
William and Mary Lou Holoboff
Joe Hornstrom
Jim Howell
Earle B. Hoyt Jr.
Paul Huddy
John Hudson
Thomas Hulen
Jeff D. Jenson

Eric Johnson
Judy L. Johnson
Larry Jonas
Chad Jones
Julie Jones
Jeff Kammann
Mark Karvoski
Jim Kasper
Jennifer Katcher
Ron Kearns
William A. Keebler
Emily Kenny
David P. Kelly
Patricia Kenyon
Steven M. Kehrwald
Kelsey Kidd, MESc
Brian Kimball
Earnest Kimbrell
Mark Kinder
Ken R. Krause
D. Kritz
T.W. Kreuser
John Kulberg
Lampbert
Anna Lands
Larry Langstaff
Cal Lash
Jody Latimer
Keith A. Lengkeek
Dale Little
Dan Loghry
Doug Luger
Marshall MacFarlane
Gary Major
Dr. Christian Mannsfeld, MD
Don Martin
Mary Martin, Ph.D.
Anthony J. and Debbie W. Martins
Clint Matkovich
Rue Mattice
David McCasland
James K. McCasland
Alan McGee
Mike McElrath
Marjorie Mead
Mike Micallef
Janet Millard
D. Page Misenhimer, Jr. CPA, PFS
Kevin D. Mitchell
Bob Morse
Jeff Mortensen
Kristine Mullenaux
Mike Nickoloff
Franklin and Jean Olmsted
Bart J. Page, Esq.
Brian Payne
Mike Pellegatti
Dave Pence
Jean Public
Craig Rabb
Steve Reamer
Dana Remfrey
Douglas Rich
Jenny Roberts
Larry E. Roberts
John Robinson
Walter Rykard
Bob Schaal
Gregory Scott
Carl Shores
Clark Simmons
Ted Smith
Don Smoot
William A. Soder
Dennis Sowards
Deb Sparrow
Steven N. Spearman
Richard D. Sprague
Paul Steinhoff
Donald Stogdell
Michael Steward
Glen Stilson
Anne M. Stine
Jason Sullivan
Rachel Swadener
Patricia Swain
Halina Szyposzynski
Bryan Terrell
John Teeter
Garfield Thomas
William C. Thornton
Deborah J. Townsend
Phillip D. Townsend
Ed Turner
Clyde W. Uber
John Underwood
Jim Unmacht
Tracy Unmacht
Ken R. Waddill, Jr.
Gregory Warner
Steve Watson
Steven C. Weinstein
James H. Wilkey
Jean E. Wilson (2 letters)
David L. Wolf
Randy Wolff
David Womack
Lloyd M. Wundrock, ChE, CHMM
Raymond Zoratti

The comments received expressed support for all three Alternatives: A, B, and C, with some expressing an interest in mountain lion control efforts in general, and some suggesting Alternative B or C with modifications. A few comments received were neutral or general in nature, and some pointed out editorial changes that should be made. The following is a discussion of the specific issues, questions or suggestions brought up by one or more commenters and the Service's response to these comments:

Mountain lions should not be lethally removed and should only be translocated.

The idea of only translocating mountain lions is covered in the EA under Section 3.4.2 (Translocation of all Offending Lions Alternative). The option of translocating mountain lions is part of Alternatives B and C.

Lion translocation should be completely removed as an option.

While mountain lion translocation would be unlikely, it remains in the EA in both Alternatives B and C so it is available as an option in the future.

Predation is good for the herd because it removes sick or weak animals and prevents the spread of disease.

Weak or sick animals are more prone to predation; however, mountain lions also kill healthy animals. Ross et al. (2007) found that more than one-third of mountain-lion killed bighorn sheep had apparent or possible disabilities, however, all the disabilities described were physical (e.g. limping, injuries, extreme age, isolated from herd) and not disease-related. This suggests that about 2/3 of all mountain-lion killed bighorn in that study were healthy, without apparent weakness or disease.

By visiting locations where satellite GPS-collared mountain lions KM01, KM02, KM03, and KM04 stopped and spent time, biologists found and examined a total of 28 desert bighorn sheep that had been killed and consumed, or partially consumed, by each lion. Bighorn mortalities attributed to mountain lions were examined carefully for any clues as to the condition of the bighorn before its death, including deformities, growths, evidence of disease, and condition of bone marrow. Evidence was recorded at each site indicating that the bighorn sheep were killed by the lion and not scavenged, such as areas disturbed by struggle, including rolled rocks and broken branches, blood and other body fluids splashed on the ground, and horn sheaths broken off during a struggle. Biologists also looked specifically for characteristics specific to mountain lion kills, such as broken necks, broken open long bones, torn open throats, crushed skulls, and canine punctures. In only one case where mortality was attributed to mountain lions was definitive evidence of a disability known: the collared ewe in question was observed limping several weeks before she was killed. However, animals with injuries are sometimes still capable of breeding and may remain productive members of the population.

In 2006, refuge staff did investigate a mountain lion-killed bighorn ram carcass that was found to have chronic sinusitis, a secondary bacterial infection caused by necrotic bot fly larvae that are deposited in the nostrils of bighorn sheep. Chronic sinusitis is not a contagious disease that spreads from bighorn to bighorn. It is occasionally noted in many populations of desert bighorn but is not considered common, nor does it cause epidemics or dieoffs. Although a bighorn with chronic sinusitis would be more vulnerable to predation, there is no evidence that removal of bighorn with chronic sinusitis by predators would slow or prevent the spread of the disease.

Stop hunting desert bighorn sheep.

Some commenters opposed hunting on a general basis, while some did not understand why a population in decline would continue to be hunted. This topic is discussed in the EA in Section 4.6.6. As stated there, the hunt program is very conservative and should not significantly impact the bighorn sheep population. The harvest of a limited number of males will not affect the reproductive capacity of the herd since a few rams breed multiple ewes. Though hunters target the oldest and largest rams, the reality is that the number of tags issued represents only a small percentage (<20%) of the available older (Class III and Class IV) rams, and not all hunters are successful. This leaves a large portion (>80%) of mature rams unharvested. Historically, hunting has been a part of the management of the Kofa bighorn sheep herd for nearly 50 years with no apparent impact to the population. Data from our current population models support this.

Trophy hunting and translocations affect genetics, population recovery, and behavior of sheep.

Many commenters expressed concern that the bighorn decline observed could be due to the genetic impacts of selectively removing only "trophy" rams during hunts or "prime" ewes during past translocation efforts. Hunting and translocations are harvesting regimes that differ from natural predation. However, there is little empirical evidence of long-term genetic consequences of hunting (Harris et al. 2002). Although in most cases hunters prefer to harvest large rams, it does not follow that hunting removes relatively more fit individuals in all cases. Hunters selecting for large-horned individuals remove primarily old individuals, not necessarily those with genomes conducive to producing large secondary sexual characteristics (Harris et al. 2002). Also, changes in allele frequencies caused by selective hunting of large males may be buffered by the genetic contributions of females, which will have most of the same alleles as males but are subject to differing selective pressures (Harris et al. 2002). In addition, Hogg and Forbes (1997) discovered that younger rams using "unconventional" courting tactics were surprisingly effective in contributing their genes to subsequent generations. Therefore, a variety of alleles in bighorn might be transmitted to subsequent generations by smaller, younger rams that are unlikely to be affected by selective hunts (Harris et al. 2002). Of a variety of possibilities in which selectively harvesting rams might reduce overall fitness in bighorn herds, no effects have been found on bighorn demographics (Milner et al. 2007, Singer and Zeigenfuss 2002, Shackleton 1991, Jorgenson et al. 1997). It is probable that there are long-term changes in allele frequencies in a hunted population over decades, but these changes would be gradual. While these changes may bear further investigation, they could not have caused the steep decline observed in only 6 years. Predation is now a larger source of mortality in the population than hunting.

The effect of translocations has been even less studied, except in the case of the receiving population. The population modeling demonstrates that the translocations conducted from 2001, 2002, and 2005, while causing a small decrease in the total population of bighorn, could not alone account for the population decline observed. It is true that many bighorn, mostly ewes, were removed from the refuge nearly every year from 1979 through 1994. No population decline was noted in the years those transplants occurred, nor for 6 years afterwards. There was no active selection in determining which animals were removed, and although the genetic and

demographic impacts of removing those animals is not yet known, the individuals removed represented a small percentage of the total population at the time. The Service intends to include these impacts in upcoming models, and as has been noted in previous sections of this document, further transplants are suspended indefinitely.

The Service should consider having another desert bighorn sheep population objective for "optimal levels" of sheep. This would be less than a population objective for translocations of sheep.

The current population goals for desert bighorn sheep are based on the existing plan for the Refuge, the *Kofa National Wildlife Refuge & Wilderness and New Water Mountains Wilderness Interagency Management Plan and Environmental Assessment.* The population objective considers the Refuge an integral part of regional bighorn sheep conservation and sets goals for bighorn sheep based on future translocation needs. The adjustment of important Refuge program goals are normally addressed during the development of a Comprehensive Conservation Plan for the Refuge. This planning effort for the Refuge is not expected to begin until 2014.

The EA only partially evaluates the effects of wildlife water developments. These developments have improved the habitat for mountain lions.

Certainly, mountain lions drink free water when it is available and the EA briefly discusses the impact of existing wildlife water developments and future projects to evaluate them in Section 2.4.2, Issues Not Analyzed in Detail with Rationale. Most of the Refuge wildlife water sources that have been modified or added have been in existence since at least the 1940s, and 11 are natural springs. If wildlife water sources allow mountain lions to inhabit the Refuge, these waters have been present since the 1940s and do not explain the recent immigration or increase in mountain lion numbers.

Building additional water sources for wildlife should be included.

The construction of new permanent and temporary wildlife water catchments is briefly discussed in Section 2.2 ; however further analysis as part of the Proposed Alternative would require another EA. Additionally, it takes a great deal of time, up to years, for desert bighorn sheep to establish use of new sources of permanent water where no water existed in the past. The benefits of reducing mountain lion predation should be more immediate.

Sport hunting of mountain lions on the Refuge should be established.

This was considered and is described in Section 3.4.1, but sport hunting was eliminated from further consideration since it is unlikely to be an effective way of reducing mountain lion predation on desert bighorn sheep.

Add an additional factor to be considered when determining whether to remove a lion if the sheep population is between 600 and 800 animals. That would be: g. Level of criticality of anticipated translocations.

The change has been made to the EA.

The management of desert bighorn sheep should not be the primary focus of the Refuge. Other Refuge purposes such as biodiversity, biological integrity, and wilderness must also be considered.

Although President Franklin D. Roosevelt's Executive Order 8039 that established the Refuge on January 25, 1939 does not specifically mention desert bighorn sheep, the conservation of bighorn sheep was clearly the primary motivation behind the Refuge's establishment. Documentation of this intent, including quotes from a 1938 letter from the Arizona Democratic State Central Committee and the Arizona Game Protective Association are now in Section 1.0 Introduction. The Service believes that desert bighorn sheep conservation on the refuge is a priority. The current policies, regulations and statutes that guide the management of refuge lands, including biological integrity and the establishment of wilderness, are important mandates as well.

Is there adequate funding to implement Alternative B?

Funding to initiate Alternative B would be a high priority within the Service and would be a very likely recipient of additional appropriated funds. Supplemental funding to implement Alternative B would be sought through partnerships with other agencies and conservation organizations. Conservation actions that have been implemented in the past on the refuge have been cost-shared very effectively with the AGFD and several conservation organizations. The Service expects to continue and expand these partnerships.

Alternative C should be implemented because: a) a similar effort in New Mexico has reduced the predation rate, b) it is more cost effective than Alternative B, and c) less bighorn sheep are lost to predation.

Currently, Refuge Wilderness Policy (610 FW 2.16) states that "We will direct control at the individual animal(s) causing the problem…" which means that Alternative B is the only action alternative that could be undertaken in Refuge wilderness consistent with Service policy. Alternative B should be attempted before any relief is sought from the existing Service policy**.**

What are the consequences of removing female mountain lions and kittens?

It is not the intent or expectation that implementation of the Proposed Action would focus on the removal of a female mountain lions with spotted kittens from the Refuge. However, the removal of offending female mountain lions with spotted kittens may be warranted if they are negatively impacting the recovery of the Kofa sheep herd based on the best scientific data available at the time. Simultaneously, all practicable efforts would be undertaken to humanely remove the kittens by lethal means or translocation when practicable. DNA evidence from mountain lion scat

suggests that as many as 3 female mountain lions may be using the Refuge and surrounding areas, so removing a female would not necessarily disrupt the local breeding population.

Under the proposed plan, nearly every mountain lion on the Refuge would end up dead.

It is not the intent or expectation that implementation of the Proposed Action would remove all mountain lions from the Refuge. However, offending lions would be removed from the Refuge if they are negatively impacting the recovery of the Kofa sheep herd based on the best scientific data available at the time. Therefore it is highly improbable that the management of offending lions could result in the removal of every, or nearly every, mountain lion from the Refuge for the following reasons: 1) trapping and removing lions from the Refuge has, to date, proven relatively difficult and time consuming 2) any such impact to the lion population on the Refuge would only be temporary as lions are expected to continue immigrating from areas outside of the Refuge, as well as occupy home range territories that include both Refuge and non-Refuge lands 3) if the Kofa sheep herd is above 600 animals, such intensive lion management would probably not be necessary or implemented.

The EA should evaluate global warming.

The EA briefly discusses global warming (climate change) in Section 2.4.2 Issues Not Analyzed in Detail with Rationale. There is compelling evidence in Section 4.0 Affected Environment, that predator management is the most likely action to increase the number of desert bighorn sheep on the Refuge; global warming is outside the scope of this EA**.**

The EA should evaluate trophic cascades related to predator management.

A trophic cascade occurs when the limiting effect of predation spills over from prey to lower trophic levels, for example from carnivores to herbivores to plants (Creel and Christianson 2009). The most well-known recent example of this occurred in the Greater Yellowstone Ecosystem when wolves (*Canis lupus*) were reintroduced and began consuming elk (*Cervus elaphus*). There is some consensus that wolves either directly (by decreasing elk numbers) or indirectly (by changing elk behavior) caused an increase in willow growth (Beyer et al. 2007). However, there is some conflicting data on the mechanisms and results of predation on the trophic cascade: Creel and Christianson (2008) found that after wolves were introduced to the Greater Yellowstone Ecosystem, elk were found to consume more willow (Salix spp.) as a percentage of their diet) which is contrary to earlier studies.

It is unknown to what extent trophic cascades operate on Kofa Refuge. However, since desert bighorn sheep diet is highly variable and a variety of species of plants are consumed, a trophic effect on any particular plant species resulting from the removal of desert bighorn sheep by mountain lions is unlikely. In addition, desert bighorn sheep have existed for decades on the Refuge without significant mountain lion predation, with no ill effects observed to vegetation or other ecosystem components.Unlike some other vegetation communities where grazing or

browsing by a variety of herbivores is a dominant force in the landscape, Sonoran desert vegetation is influenced more by variation in precipitation than herbivory (Marshal et al. 2005), especially as ungulate densities average only about one animal per square mile on the Refuge.

The EA should evaluate drought and reduced forage quality.

Drought effects and reduced forage quality are believed to be only marginally responsible for the drop in desert bighorn sheep population estimates on the Refuge. Studies of bighorn sheep condition including body fat measurements are ongoing in cooperation with New Mexico State University, but there have been no immediate concerns identified. The average population estimate of desert bighorn sheep (760) on the Refuge obtained from aerial surveys since 1980 includes several periods of below average rainfall including 1989 (1.67") 1991 (4.82"), and 1999 (3.81") through 2000 (4.22") (Rainfall totals are from the long-term weather station at the King of Arizona Mine where an average of 6.7" of rainfall was measured per year since 1981). The estimate of the number of desert bighorn sheep rebounded in 1994 to 887 sheep from a low of 638 in 1991. A similar rebound in sheep population estimates has not occurred since the low of 390 animals in 2006, in spite of above average rainfall in 2004 (11.28"), 2005 (10.52") and near average rainfall in 2007 (6.15"), 2008 (7.47"), and 2006 (4.3"). The estimated population of desert bighorn sheep in mountain ranges near the Refuge, including the Imperial Hills, Eagletail, Trigo, Dome Rock, Tinajas Altas, and Gila Mountains, have remained stable or even increased at the same time that the drop in population estimates was observed on the Refuge.

The EA should evaluate disturbance of desert bighorn sheep by humans involved in hunting or other recreational activities.

While estimates of refuge visitors have remained between 50,000 and 60,000 per year since the installation of traffic counters in 1994, the Service has little information on the number of visitors entering bighorn sheep habitat, the timing of those visits, and whether or not bighorn sheep were disturbed. The effect of recreation on desert bighorn sheep is another identified information need in the *Investigative Report and Recommendations for the Kofa Bighorn Sheep Herd.*

The EA should evaluate desert bighorn sheep diseases.

Bighorn sheep captured for radio-collaring in 2007 were tested for pneumonia and pneumonia-like diseases and scabies and were found to be unaffected, as described in Section 4.6.3 in the EA. . Similarly, bighorn sheep captured in the past for transplants or radio-collaring have been tested additionally for blue-tongue virus, hemorrhagic disease, chlamydia, bovine respiratory syncytial virus (BRSV), contagious ecthyma (ICE), Johnnes' disease, and brucellosis. In some animals, a titer was found suggesting previous exposure, and potentially, immunity, to some of these diseases, but no active disease was found. One animal (a yearling ram) was found to have

active contagious ecthyma in the capture in 2005 (lesions on the nose and on one foot), and periodically, bighorn sheep are found to have been affected by sinusitis. Both of these conditions are relatively common in sheep, but usually do not kill sheep outright. No die offs of sheep have been observed.

The EA continues to describe a "significant decline," when the data are so variable that there is no significant difference from a statistical perspective.

Bighorn sheep population estimates derived from aerial surveys are highly variable, but they are the best available indicator of the population. It is true that confidence intervals on the population estimates are wide. The Service is currently investigating its methods to ensure that the confidence intervals are being calculated correctly. However, the population estimates represent the best available information at this time, and the Service is confident that the population trend is valid and that the decline is large enough to warrant action. The Service also believes that the potential negative consequences of taking no action based on limited uncertainty in the data outweigh the potential negative consequences of implementing the Proposed Alternative. In other words, doing nothing to avert significant mountain lion predation on bighorn sheep could have devastating consequences for the long-term recovery of the Kofa sheep herd and other desert bighorn sheep populations in the southwest due to the lack of available animals for translocations. Conversely, implementing the Proposed Action Alternative would likely only result in the temporary reduction of lions from the Refuge and would not significantly impact lion populations on a regional or statewide basis.

The population estimate of desert bighorn sheep went up in 2007 to 460 from an estimate in 2006 of 390. This increase took place without the removal of any mountain lions. How can this be explained?

Some annual variation in sheep population estimates is to be expected because the number of sheep changes depending on the number of births versus deaths, and also because of statistical variations that are inherent in any survey and estimation procedure. In 2008, the estimated population decreased again to about 430 sheep. Because of this expected variance in estimates, there may be no real difference between 390, 460 and 430. It is apparent though, that the population of bighorns did not continue to decrease during this 2 year period, which was good news. One offending lion was removed during 2007 and a second in 2008, so these removals could have had some positive effect on the sheep population.

What is the desert bighorn sheep carrying capacity of the Refuge? The carrying capacity should be calculated based on vegetation.

No one can really know what the carrying capacity of the Refuge is for desert bighorn sheep. Carrying capacity is a theoretical concept and more a mathematical abstraction than a measurement of sustainable population size in variable environments (MacNab 1985) – in the Service's own modeling of the Kofa bighorn sheep herd, carrying capacity (K) is the population size at which the per capita growth rate equals 0, and which, based on population surveys, is modeled to be 845 animals (see

Appendix D). However, in reality carrying capacity depends on many constantly changing factors like rainfall, plant nutritional state, inter- and intraspecies interactions, etc. McLeod (1997) demonstrated that carrying capacity in variable environments (such as the Sonoran Desert that has variable and patchy rainfall from year to year) does not represent sustainable herbivore density. Vegetation based methods of calculating carrying capacity cannot take into account the rapid rate of change of vegetation and variable plant biomass inherent in stochastic environments (McLeod 1997). Because of this, the Service and AGFD use a long term (20 years) average of the actual population when it was fairly stable as an estimate of carrying capacity. Likewise, minor variation in the bighorn population estimate and targets are expected from year to year – numbers are generally not treated as "hard and fast" but used to assess the overall trend of the population. To measure plant numbers and nutritional status and the many other changing variables to try to estimate how many sheep the range could support from year to year would be no better than guesswork and would require more resources than the Refuge could afford.

Bighorn habitat should be improved regionally in order to provide more resilience to mountain lion predation.

The AGFD, along with other agencies and volunteer organizations, have been doing just that for many years throughout the areas surrounding the Refuge. Distribution and availability of water has been improved, movement corridors have been identified and attempts made to protect them and improve linkages across highways, areas of illegal off road activities in bighorn habitat have been identified and restrictions put in place.

Not enough alternatives are evaluated in the draft EA.

The EA meets or exceeds all NEPA requirements for developing and analyzing the reasonable alternatives, including no-action and proposed action alternatives**.** NEPA regulations require federal agencies to "identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions on the quality of the human environment [40 CFR 1500.2(e)]." Sections 3.0 through 3.4.3 of the Draft EA thoroughly analyze three alternatives: 1) Alternative A, the No Action Alternative – Continue Current Management Efforts; 2) Alternative B, the Proposed Action Alternative – Conduct Limited Removal of Mountain Lions; and 3) Alternative C – Indiscriminate Removal of Mountain Lions. Three additional alternatives were considered but not analyzed in detail; 1) Sport Hunting Alternative; 2) Translocation of All Offending Mountain Lions Alternative; and 3) Nonlethal Harassment Only Alternative. This list and corresponding analyses clearly represent an appropriate range of reasonable alternatives, including a preferred and no-action alternative, to meet the requirements of CFR 1500.2 and other NEPA regulations.

Service Policy 610 FW 2.20 permits predator control on wilderness lands but only to "correct or alleviate identified impacts on native fish, wildlife, plants, or their habitats" and only "on the individual animal(s) causing the problem …" The Proposed Action Alternative, therefore, is consistent with this policy because it only authorizes the removal offending lions from the

Refuge. Further, although Alternative C is a potentially viable alternative if the Service determines it is the best alternative to achieve its objectives and exempts the Refuge from the policy based on the current purpose and need.

The EA meets or exceeds all NEPA requirements for developing and analyzing the Alternatives including the Proposed Action**,**

The 60-day draft EA comment period was not extended to 90 days.

The Service used all practicable means and measures to provide the public with an adequate comment period and to facilitate public involvement. NEPA regulations (40 CFR parts 1500-1508) do not identify or require specific comment periods for environmental assessments. Rather, CFR 1500.2(d) requires federal agencies to, "Encourage and facilitate public involvement in decisions which affect the quality of the human environment." The 60-day comment period that the Service provided for the Draft EA was sufficient to allow over 200 individuals, organizations, and agencies to comment on the Draft EA. An informational public meeting was held in Yuma, Arizona on the evening of September 16, 2009 with 60 members of the public attending, and the Service met with six environmental organizations and the media in Tucson, Arizona on September 9, 2009 to further facilitate public involvement and input. Any further delay in completing the EA and implementing necessary actions will likely contribute to the continuing decline in the Kofa desert bighorn sheep herd.

No legitimate purpose and need was established in the draft EA.

The Service clearly and thoroughly identifies and discusses the purpose, need, and background for the Proposed Action Alternative in Sections 1.0 through 2.5 of the Draft EA, consistent with NEPA regulations. The Service has included additional information throughout these sections of the EA, including information that further illustrates the importance of bighorn sheep in the establishment of the Refuge (for example, Lockart 1938), and updated information identifying known predation on Kofa bighorn sheep by mountain lions.

The purpose and need given in the draft EA is not consistent with Service laws and policies.

The Purpose and Need is consistent with Service laws and policies.

The affected environment was not adequately described in the draft EA.

CFR 1502.15, which applies to the more in-depth Environmental Impact Statement (EIS), states "...a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced…Verbose descriptions of the affected environment are themselves no measure of the adequacy of an environmental impact statement." As such, the Affected Environment is more than adequately described in Sections 4.0 through 4.9 of the EA, including climate, habitat, recreation, and thorough discussions and references

regarding bighorn sheep and mountain lion life histories, population ecology, and interactions. Additionally, the Service updated the EA to include new information that has become available since the Draft EA was published and released for public review, including results of DNA analyses, population modeling, and known predation of bighorn sheep by lions on the Refuge.

The Service failed to disclose all relevant information and data in the draft EA.

The Service disclosed all relevant information and citations related to the development of the Alternatives in the Draft EA, including data summaries, reports, plans, and policies. Further, the Service will continue collecting additional information with assistance from other agencies and organizations beyond the completion of the EA, including annual bighorn sheep surveys, mountain lion genetics and scat composition analyses, mountain lion and bighorn sheep telemetry and movement information.

The direct, indirect, and cumulative impacts were not completely discussed in the draft EA.

The Environmental Consequences are thoroughly described in the Environmental Consequences Sections 5.0 through 5.6 in the EA, including the direct, indirect, and cumulative impacts anticipated for each of the Alternatives. Additional information has also been added to the EA concerning the potential impacts to bighorn sheep and mountain lion populations.

An Environmental Impact Statement is required.

The purpose of an EA is to determine whether a proposed action could have significant impacts on the human environment. CFR 1501.3(b) states that, "Agencies may prepare an environmental assessment on any action at any time in order to assist agency planning and decision making." Further, CFR 1501.4 asserts that, "In determining whether to prepare an environmental impact statement, the Federal agency shall…(c) Based on the environmental assessment make its determination whether to prepare an environmental impact statement." If it is determined that the Proposed Action would not result in significant impacts to the human environment, then the Service will prepare a finding of no significant impact. If it is determined that the Proposed Action Alternative would significantly impact the human environment, then an EIS would be required.

Wilderness requirements should not impede the implementation of Alternatives B or C.

Wilderness designations on refuge lands are not meant to negate the original purposes for those specific units of the Refuge System. Rather, the purposes and mandates related to wilderness become supplemental purposes for the refuge. They are considered and harmonized with existing refuge purposes to deliver the appropriate conservation program for that refuge. In this case, wilderness requirements would not prevent the implementation of Alternative B, but may affect the manner in which it is carried out. This is discussed in detail in the Minimum Requirement Decision Guide which was prepared by the Service and is appended to the EA.

Please put the most up-to-date information in the EA.

Section 4.0 Affected Environment has been updated to include the latest information including, but not limited to, mountain lion monitoring data, genetic information gained from the analysis of mountain lion scat, the causes (when known) of additional radio-collared desert bighorn sheep mortalities, and population modeling.

The desert bighorn sheep survey results for 1980 and 1983 are missing from Figure 2 and this is not explained.

This is now correctly displayed and explained in Section 2.2 and Figure 2 in the EA. In 1980 was the first helicopter survey was conducted on the refuge and is considered a pilot study. Because the technique was still being refined, the population estimate is not included for consistency. Although the summary data sheets for 1983 exist, the raw data sheets are missing. These data sheets are required to use the Kofa Group Size Estimator to generate a population estimate. Therefore there is no comparable population estimate from 1983 and it has been left out of the data set.

Captive breeding of desert bighorn sheep should be considered as an alternative.

Currently the state of New Mexico has a captive herd of bighorn sheep that they use for transplants. However, maintaining a captive herd is very labor and cost intensive and the sheep tend to be prone to disease outbreaks and declining genetic variability. Though a captive herd could possibly supply some of the sheep needed for transplants, it would be many years before a substantial number would be available. This option would not address the declining condition of the Kofa herd and would not help the Service to meet population objectives for the Refuge.

Native American Tribes should have been consulted during the EA process concerning recollections of mountain lions and their ancestors' mountain lion recollections, and any religious concerns.

During the April 24 to June 23, 2007 Scoping Period, the Service sent out 4,007 letters and emails to potentially interested parties, including all of the Native American Tribes in Arizona and neighboring California. No response was received during the scoping period or during the August 4 to October 2, 2009 Draft EA comment period.

The Service has a clear obligation arising from statutory requirements and executive orders to take prompt, timely active management measures to ensure the conservation and enhancement of desert bighorn sheep on the Kofa Refuge.

The Service details the purposes of the Refuge, the mission of the Refuge System, and the supplemental purposes imposed by wilderness designation in Section 1.0 of the EA. Sections 1.2 and 1.5 of the EA discuss the importance of the proposed management actions as they relate to obligations arising from statutory mandates and other policy requirements. These sections of the EA clearly describe the importance of desert bighorn sheep conservation as it pertains to meeting the purposes of the Refuge. Section 5.2.5 and Appendix E discuss in detail the implications of wilderness designation and how the active management of wildlife on the Refuge meets policy and legal requirements.

Appendix D – Population Modeling

Mountain Lion Predation Can Generate Reported Population Declines of Desert Bighorn Sheep at Kofa National Wildlife Refuge

Introduction

The purpose of this modeling exercise is to evaluate the potential of predation to be a plausible factor in causing a rapid in the population of desert bighorn sheep (*Ovis canadensis nelsoni*) in the Kofa National Wildlife Refuge (NWR). Here, a rapid decline is defined as a 50% reduction in the population over a 6 year period. This reported decline in the bighorn sheep population coincides with the recent documentation of breeding mountain lions (*Puma concolor*) that use the Refuge (Smythe 2008).

Our method relies on a simple population growth curve founded on demographic parameters measured from the Kofa NWR bighorn sheep population and gained from the literature, so that the modeled population stabilizes at *K* (carrying capacity). For each time step in the model, we simulated predation by removing female and male bighorn sheep. We then quantified the response of the bighorn sheep population to these simulations.

This population, like most populations of ungulates, fluctuates in response to many internal and external factors (Saether *et al.* 1997). Accounting for these fluctuations would involve a more complex model that incorporates variation in variables such as *K* and λ (finite rate of increase), while potentially including other terms to account for environmental stochasticity. Here, our intentions are not to generate such a model of the Kofa NWR bighorn sheep population that incorporates multiple variables. Therefore, we are not determining what caused the bighorn sheep decline, nor can we conclude if predators are responsible for the decline. (As above, this objective would involve testing other variables, such as evaluating sheep numbers and precipitation levels [as a surrogate for forage quality or quantity] that could dampen or accentuate any decline). Instead, we generate a model of bighorn sheep numbers that stabilize at *K*, and then explore to what extent predation, and no other variables, could reduce bighorn sheep numbers. This analyses responds to the question "If predators are in fact the factor responsible for the decline, then what amount of predation would it take to cause the decline, and is this amount of predation reasonable given our understanding of the system?" Results then inform us the extent to which predation could be a contributing cause in reducing the Kofa NWR population of desert bighorn sheep.

Analyses incorporate predation from one to four mountain lions. Each level of predation contains 35 different scenarios, as predation can occur unevenly across bighorn sheep age classes (*e.g.* mostly young sheep, mostly old sheep, mixtures of young and old etc.). The population response of the bighorn sheep herd is reported at six and 10 years time after predation begins, based on scenario averages. We reported the number of years necessary to halve this population

were predation levels unabated. We also simulated the amount of time it takes a population of halved bighorn sheep to recover.

The number of bighorn sheep killed by mountain lions in our model is based on the actual predation rates calculated from mountain lions inhabiting Kofa NWR. Predation rates estimated from Kofa NWR are not comparable to predation rates from mountain lions on bighorn sheep populations elsewhere. Such a comparison is invalid, as those populations may differ in their density with respect to K, which ultimately determines the consequences of mortality whether caused by predation or other factors (*e.g.* McCullough 1989, Bartmann et al. 1992).

The modeling herein simplifies a complicated biological system. However, it is this very simplification that helps to provide insight and understanding into the prominent characteristics and behavior of this system.

Model Development

Our analyses of desert bighorn sheep populations are based from the following logistic model (Miller et al. 2002):

N_{t+1}=N_t+($\frac{(K- Total[N_t])}{K}$ *(M-I)* N_t) where,
N_t = Size of the sheep population at time t.
N_{t+1}= Size of the sheep population at the next time step (t+1).
K = carrying capacity.
M = Leslie Matrix.
I = Identity Matrix.

so if M = $\begin{pmatrix} f_0 & f_1 & f_2 & f_3 \\ s_0 & 0 & 0 & 0 \\ 0 & s_1 & 0 & 0 \\ 0 & 0 & s_2 & 0 \end{pmatrix}$...

(with f_i = fecundity of age class i, and s_i = survivorship of age class i)

then I = $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Calculations rely on matrix algebra, with the model incorporating density dependence with this equation:

$$\frac{(K - Total[N_t])}{K}$$

For example, when the population size is at carrying capacity (*i.e.* $N_t = K$), then population growth = 0. In other words, the population at the next time step is simply the population size at the previous time step, so the population stays at *K*. If the population size is very low with respect to *K*, then this equation ~ 1. Therein, population growth is maximized when population size is low relative to *K* and decreases as the population approaches *K*. Were N_t to be above K, the equation becomes negative, so the population declines to K. The equation, therefore, forces a population to K, where it stays.

We incorporated predation by removing sheep prior to the multiplication of the Leslie matrix and the population vector. For example, were we starting with a population of 600 sheep and wanted to model the removal of 15 sheep by mountain lions, then 585 sheep distributed in the appropriate age classes should constitute the initial population vector (N_t).

Parameters

Below are the population estimates of desert bighorn sheep for Kofa NWR (red points). The estimates are linked with a third order interpolation for display (blue line).

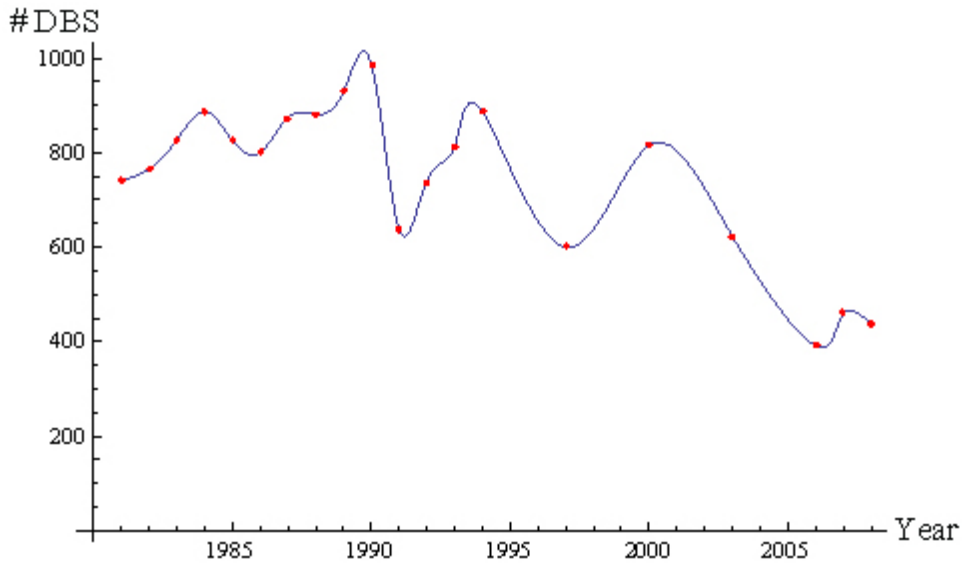

Figure D1: Population estimates of desert bighorn sheep over time at Kofa NWR.

We used data on population size from 1981 – 1994 to estimate *K*. Population estimates during this time period were consecutive (except 1983 for which we obtained by averaging counts of 1982 and 1984) and no predation by mountain lions was documented during this time (Figure D2).

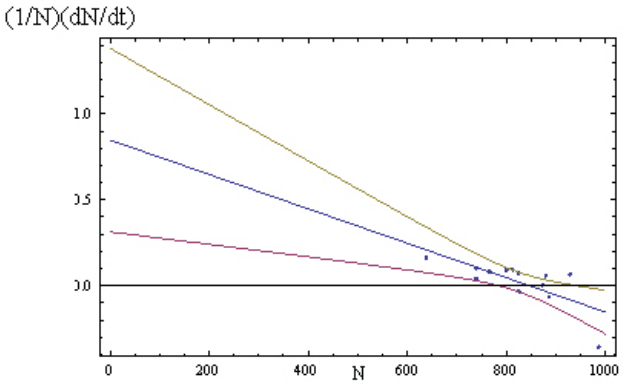

Figure D2: Per capita growth rate of the Kofa NWR desert bighorn sheep population, $(\frac{1}{N} * \frac{dN}{dt})$ *against population size (N).*

These points receive a linear fit (y = 0.848 - 0.001 * x , blue line with 95% confidence intervals [olive and maroon]). We estimated *K* from the x-intercept of the fitted line (here 845 sheep [788 - 905 from 95% CI's; Gotelli 1998]).

Life history parameters

One of the best ways to understand changes in population size is to model them with a life table (Leslie Matrix). An assumption of this approach is a stable-age distribution, where the proportion of individuals in each age class remains constant over time. Necessary variables include age-specific survivorship and birth rates for each age class of bighorn sheep, fecundity and reproductive output. Reproductive output is the per-capita surviving births in each age class, calculated as the per capita birth rate multiplied by the survivorship probability for age class zero (into which all newborns are placed). This product yields the number of individuals in age class 0-1 for the following year.

Modeling can occur in a number of ways and we took two broad approaches. The first is to mode females first, exclude lambs, and then add in males and lambs later. Therefore we modified K, only taking 60% since 60% of the population are females, and taking a further 9% to remove lambs (see below). Total K for this population is 847, and when modified for females aged one to 15 is 457. We then modeled the population with a high λ of 1.17 (based on estimates of λ from an expanding ungulate population, Remington 1989 and Gaillard et al. 2000), and founded on survivorships calculated from Kofa NWR and couched by survivorships of predation free and expanding bighorn sheep populations elsewhere (Remington 1989, Festa-Bianchet et al. 2006). We also ran models with survivorship obtained from the Kofa NWR sheep population, and guided by published values (Festa-Bianchet et al. 2006). The, λ was 1.07.

A third evaluation modeled male and female bighorn sheep together, using survivorships based on those calculated at Kofa NWR and published from expanding, mountain lion-free populations of bighorn sheep elsewhere (Milleret al. 2002, Festa-Bianchet et al. 2006). Lambs

were excluded from these calculations but subsequently added in (by adding in 9% of the resulting population sizes of males and females). In these analyses, λ was 1.25.

We could not quantify λ from bighorn sheep population surveys conducted at Kofa NWR as the majority of surveys occurred with the population at or near *K*, such that the mean λ was 1.02. The higher the λ is, the less of an effect that predation has on reducing bighorn sheep numbers. Therefore, we obtained λ from published values of expanding ungulate populations.

Our modeling approach assumed sexual maturity of female bighorn sheep at two years, although the minimum breeding age may be as young as 13 months (Berger 1982). Moreover, we allowed each female aged two to 16 to produce a single lamb each year (Berger 1982, Remington 1989, Jorgenson et al. 1997) because females rarely have twins (Morgart & Krausman 1983). A maximum age of 16 is consistent with other reported bighorn sheep populations (Loison et al. 1999).

This project considers five age classes of females: lambs, yearlings, young breeders (two to seven) old breeders (eight to 13) and older breeders (13 to 16), and four classes of males: lambs, yearlings, young breeders (two to seven), and old breeders (eight to13) (Jorgenson *et al.* 1997; Loison et al. 1999, Festa-Bianchet et al. 2006). Each class has its own survivorship, representing the probability of a sheep surviving from age class x to age class x+1.

From 1980 – 1986, the lamb/ewe ratio reported for Kofa NWR was 0.22 (Remington 1989). Similarly, the mean ratio from 1980-2008 is 0.2 (U.S. Fish and Wildlife Service [USFWS] unpublished). These ratios vary from a minimum of 0.13 to a maximum of 0.36. These ratios (survivorship) are comparable to those reported in other population of desert bighorn sheep (Witham 1983, McQuivey 1978, Wehausen 1996). Kofa NWR survivorship estimates occur at a time with predation, and the other survivorship estimates for lambs from other locations seemingly come from situations with predation (based on values from Festa-Bianchet 2006). Our analyses needed to rely on lamb survivorship from locations calculated without mountain lion predation. Those chosen were based on survivorship reported in Festa-Bianchet et al. 2006, and included in Table D1.

	Females					Male			
Lambda	Lambs	Yearling	Age 2-7	Age 8-13	Age 14 - 16	Lambs	Yearling	Age 2-7	Age 8-13
Lambda 1.17	0.6	0.92	0.95	0.91	0.88	0.6	0.69	0.7	0.65
Lambda 1.07	0.44	0.89	0.93	0.82	0.76	0.44	0.72	0.74	0.7
Lambda 1.25	0.75	0.98	0.97	0.95	0.89	Modeled with females			

Table D1: Survivorship values used in these analyses. Values based on data reported in Festa-Bianchet et al. 2006, but modified to generate the respective λ, as calculated from the Leslie Matrix for females.

To explore other survivorship estimates, count data from AGFD between 1980 and 2008 indicated a yearling survivorship of 87.6 %. Jorgenson et al. (1997) reported yearling survivorship at 83.3 ± 2.5. Based on 34 collared bighorn sheep, survivorship rates for Kofa NWR are estimated at .902 from December 2007 through December 2008 (USFWS unpublished). Other groups (Jorgenson *et al.* 1997; Loison *et al.* 1999) report survival for Rocky Mountain bighorn sheep from .92 - .945 for Sheep River and Ram Mountain in Alberta Canada, respectively, for prime aged bighorn sheep (age two to seven). Jorgenson *et al.* (1997) cover survival rates for older sheep (.85-.86 [> 7 yrs]). These analyses used a survivorship estimate of .975 for young breeders and .92 for old breeders.

Bighorn sheep surveys on Kofa NWR between 1980 and 2008 indicate a population (yearling and above) of 62% females and 38% males. The trend for more females in the population follows that of all populations of bighorn sheep in the southwest (59 males to 100 females) and trends statewide of 57/100 (Remington 1989). Here the analyses rely on 60% of the population female and 40% male. Hence, a population of 800 bighorn sheep has approximately 480 females and 320 males.

Lastly, bighorn sheep surveys on Kofa NWR between 1980 and 2008 reveal the following mean age ratios of females in the population: 83.6% ± 4.4 SD adults , 7.5 ± 3.7 (SD) yearlings , 9 ± 2.2 lambs. Our analyses are guided by these means.

As long as the input parameters are biologically sensible, life history analyses can start with nearly any set of proportions of age groups, and the population will arrive at a stable age distribution with appropriate proportions of age classes (Krebs 2009). As such, we began our simulation with 439 females (+ 292 males = 731 desert bighorn sheep). Of those individuals, there were 90 yearlings, 205 young breeders (age two to seven), 117 old breeders (eight to 13) and 27 older breeders (ages 14 to16). These starting totals exclude lambs, but the population totals reported include lambs.

To count lambs, the model runs off a birth pulse. For example, in year x female lambs are determined by the number of offspring produced by adult females for that year, multiplied by .5 (assuming equal sex ratio at birth), and then multiplied by lamb survivorship. This is the number of surviving lambs that will become 1 year olds (i.e., recruits), and are therefore added into the total of a given year to obtain a total count of females.

To abate confusion over extrapolating numbers of females to a total population size, this project also modeled males. Male survivorship is presented in Table 1. Values are based on Jorgenson *et al.* 1997, and Festa-Biancet et al. 2006. The first cohort began with 84 yearlings, 184 young males and 24 old males. A vector describing the number of males in the population was then multiplied by the respective survivorship estimates per age-class. The number of male lambs moving into the yearling age-class was the same number of female lambs moving into their respective yearling age-class. A total population size of bighorn sheep for a given year was calculated by adding the total number of males with the total number of females, for that year.

Predation

Mountain lion predation on bighorn sheep at Mount Baxter in the Sierra Nevada averaged 3.76 sheep per year from 1976 – 1988 (Wehausen 1996). In the Peninsular Ranges of California, 42 bighorn sheep were predated by mountain lions in 7 years, averaging 6 per year (Hayes et al. 2000). Ross et al. (1997) report 29 bighorn sheep predation events by mountain lions during the winters (November – April) of 1985 – 1986 and 1993 – 1994. Thirteen were lambs, 9 were ewes and 7 were rams, generating an average of 7.25 kills/winter (4.4 ewes/winter). This may be extrapolated to ~15 kills (~nine female sheep) per year. The two most extreme predation events reported by Fiesta-Bianchet et al. (2006) were the loss of 15 adult and yearling ewes in a year at Ram Mountain and three per year over four years at Sheep River (both in Alberta, Canada). Logan and Sweanor (2001), relying on a sample of 126 radio-collared mountain lions, found that eight mountain lions killed 10 bighorn sheep over 10 years time. This includes a sampling bias, because bighorn sheep kills are hard to locate. That said, four stomach and 832 fecal samples revealed a more accurate biomass estimate of prey consumed with 92% of biomass mule deer, < 1 % bighorn sheep (Logan and Sweanor 2001). Hornocker 1970 also found few bighorn sheep taken by predators despite spatial overlap (one mountain lion of 46 killed two bighorn sheep over four years from a population of 125 bighorn sheep).

Four mountain lions received GPS collars at Kofa NWR from 2007-2009 and these animals were monitored to evaluate predation rates. On average, mountain lions ate 31 ungulates per year, with 45% of predation on deer and 55% on bighorn sheep. Some mountain lions also consumed lambs. The lamb totals were multiplied by .25, to account for the low survivorship on lambs. Therefore, we only counted one of every four lamb predation events. Overall, this makes for a predation average of 15 bighorn sheep per year for each mountain lion, of which eight are females and seven are males (USFWS unpublished). This mirrors high levels of predation of ewes reported elsewhere (Ross et al. 1997, Hayes et al. 2000, Fiesta-Bianchet et al. 2006). Our analyses rely on these predation levels.

Sheep Translocation and Harvest

Kofa NWR has one of the largest populations of desert bighorn sheep in the southwest, and has served as a source population for many other bighorn sheep populations range-wide. Therefore, females are removed from this population as a result of management activity. The intent is that these females will produce young to reestablish extirpated populations or bolster declining populations elsewhere. These numbers are accounted for separately within the modeling exercises.

Hunting of male bighorn sheep occurs annually on Kofa NWR. On average, 12 male bighorn sheep were removed per year from 2000 - 2008. Models account for the numbers of males removed for the first eight years. After 2008, models do not include harvest.

Analyses

Because there are many combinations describing ways that mountain lions can remove female bighorn sheep, we generated 35 scenarios describing such combinations (*e.g.* increased predation on young females versus increased predation of old females, with mixtures of each). Predation on males is spread evenly across age classes, and does not vary within a given scenario (except when modeled with females). Analyses contain one to four - predatory mountain lions, in each of the 35 scenarios, with mountain lions killing eight female and seven male bighorn sheep per year, apiece.

Model Results

Analyses began with a total population of 731 desert bighorn sheep (lambs excluded). We then incorporated predation by one to four mountain lions. The figure below is an example of model results. All scenarios included translocations and harvest.

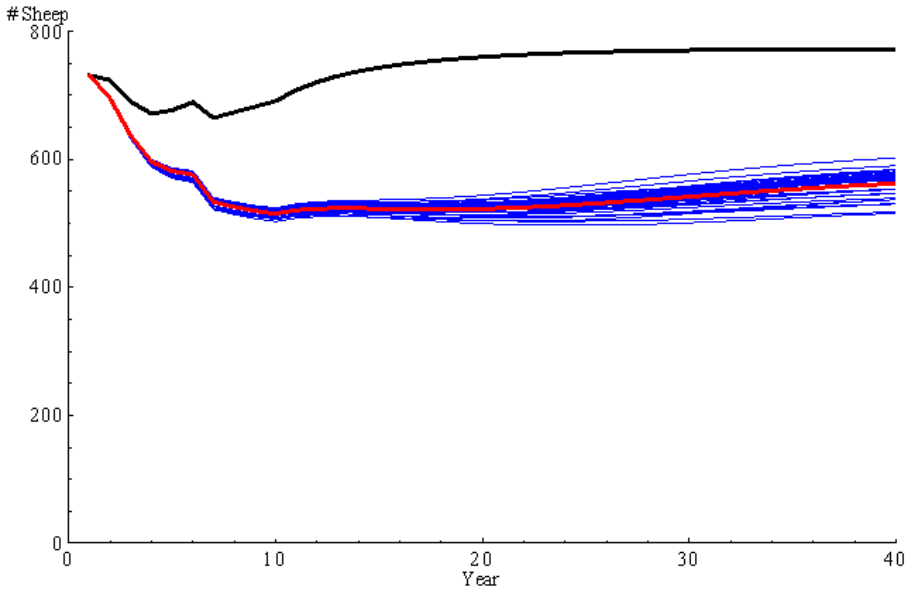

Figure D3: Example of predation modeling, with predation by two mountain lions on 16 female and 14 male bighorn sheep per year at Kofa NWR. The black line is the population trajectory for bighorn sheep, which includes harvest and translocation but not predation. The blue lines represent 35 different predation scenarios, varying by the number of bighorn sheep removed from different age classes. The red line indicates the average of scenarios.

Results are summarized in tables D2 and D3. These models indicate that the desert bighorn population could be halved in six years by three mountain lions, when considering the total population and λ of 1.07, or by four mountain lions and only considering females. It takes four

mountain lions with the total population and λ of 1.17, and five mountain lions when only considering females or a λ of 1.25 (not presented).

Table D2: Number of females (F,mean ± SD), total population size (M+F mean ± SD), and number of years taken for the population to be halved (to 400 total sheep or 231 females [no lamb]) under varying predation scenarios incorporating zero to four lions (35 predation strategies in each scenario). Analyses began with a total population of 731 sheep. Values represent scenario averages.

			Lambda = 1.17			*Lambda = 1.17*			*Lambda = 1.07*			*Lambda = 1.07*		
# Mountain Lions	Predation level (# sheep/year)		Population size M+F and lambs		# Years after predation population reaches 400	Population size F no lambs		# Years after predation population reaches 231	Population size M+F and lambs		# Years after predation population reaches 400	Population size F no lambs		# Years after predation population reaches 231
	F	M	6 years	10 years		6 years	10 years		6 years	10 years		6 years	10 years	
0	0	0	818	828	No harvest, translocation or predation	453	457	No harvest, translocation or predation	832	835	No harvest, translocation or predation	445	448	No harvest, translocation or predation
0	0	0	724	772	Harvest & translocation, no predation	410	433	Harvest & translocation, no predation	702	716	Harvest & translocation, no predation	388	402	Harvest & translocation, no predation
1	8	7	659 (4)	683 (5)	Over 30	377 (1)	388 (2)	Over 30	615 (5)	583 (7)	Over 30	346 (1)	337 (3)	Over 30
2	16	14	582 (6)	569 (6)	Over 30	341 (2)	334 (3)	Over 30	520 (7)	439 (8)	15 (1)	303 (2)	269 (5)	18 (3)
3	24	21	485 (6)	419 (.5)	12.7 (.5)	302 (2)	266 (4)	15 (1)	405 (5)	254 (2)	7 (0)	253 (2)	175 (4)	8 (0)
4	32	28	393 (3)	265 (4)	7 (0)	261 (2)	189 (5)	9 (0)	301 (3)	82 (4)	6 (0)	205 (2)	84 (4)	7 (1)

Table D3: Estimated population size (± SD) of desert bighorn sheep with predation of 0 - 4 mountain lions. Estimates are presented after 6 and 10 years, as well as time necessary to halve the population. Analyses began with a total of 800 sheep and represent scenario averages.

# Mountain Lions	Predation level (# sheep/year)	Population size M+F and lambs		# Years after predation population reaches 400 sheep
	M+F	6 years	10 years	
0	0	837	838	No harvest, translocation or predation
0	0	762	796	Harvest & translocation, no predation
1	15	709 (1)	726 (2)	N/A
2	30	646 (3)	636 (6)	N/A
3	45	584 (6)	530 (12)	11 of 35 scenarios reach 400
4	60	517 (15)	407 (33)	12 (2)

Seventy-nine bighorn sheep (64 females and 15 males) were also removed from Kofa NWR for translocation purposes from 2001 - 2005 (2001:7M, 20F; 2002:2M, 19F; 2005:6M, 25F). Rams are also harvested at varying levels every year, and 104 rams were harvested on Kofa NWR between 2000 and 2008. Without predation, these removals would cause the total population to drop to 724 bighorn sheep after 6 years and 772 bighorn sheep after 10 years when λ is 1.2.

Population Recovery

If we started with an initial population size of 400 bighorn sheep, and predation, translocation and harvest were to cease, the population would reach 800 bighorn sheep in 50 years with λ of 1.1, 19 years with λ of 1.17, and 11 years when λ is 1.25.

Discussion & Conclusions

Predation from three to five mountain lions has the potential to halve the Kofa NWR desert bighorn sheep population in nearly six years. Overall, predation has potential to reduce bighorn sheep numbers rapidly, and predation is likely to play an important role in generating the Kofa NWR bighorn sheep decline.

Density dependence and K

Density dependence refers to changing survivorship in accord with population size. For example, survivorships tend to rise when population numbers are low (*e.g.* perhaps more available food, sheltering locations), and survivorship declines when population numbers are high (*e.g.* less food, sheltering locations). Therefore, were a mean carrying capacity for bighorn sheep identified at 845 animals, survivorship should decline when bighorn sheep numbers exceed that value (deaths outnumbering births), and survivorship values would increase with bighorn sheep numbers below that value (births surpass deaths).

Most likely, carrying capacity varies from year to year as habitat conditions improve or decline. Therefore, our assumption of a constant carrying capacity (*K*) likely results in an oversimplified view of this system being modeled. In arid environments, resource availability is strongly linked to precipitation, which can vary substantially from year to year. Consequently, resource availability, and thus *K*, will vary from year to year. Indeed, during severe dry periods, intraspecific competition will increase, resulting in depressed nutritional condition, recruitment, and survival. For example, in 20 different bighorn sheep populations in the southwest, Marshal et al. (2009) reported that as the coefficient of variation for rainfall increased, density-dependent effects were less evident because resource availability, and thus *K*, varied from year to year. A potential solution would be to incorporate precipitation as a stochastic variable in the model based on the observed range of precipitation in this area during the time period being modeled.

This is a likely next step. Here, we only sought guidance as to what levels of predation would be required to halve bighorn sheep numbers in six to ten years, were predation levels consistent over those times., and to determine if those predation levels were biologically realistic.

Management implications

Our goals centered on seeking insight into the relationships between bighorn sheep removal (be it harvest, predation or translocation) and bighorn sheep population response and size. Results herein demonstrate that three to five mountain lions can halve a population of 800 bighorn sheep in approximately six years. Unfortunately, recovery can be slow. With the same parameters for which we analyzed predation, it takes ~11 to 50 years for a population of 400 bighorn sheep to rebound (to reach 845). These results send the same message: declines to bighorn sheep populations can happen relatively quickly, and it could take much time for bighorn sheep populations to recover.

We note that the Kofa NWR bighorn sheep population would be more resilient to predation were translocations not conducted. The issue, however, is moot. The main purpose for maintaining large numbers of sheep at Kofa NWR is for relocating bighorn sheep to augment or establish populations elsewhere. Were this not so, then managers would be less concerned over this declining bighorn sheep population and the cause of that decline.

Harvest also removes sheep, but only males. These males contribute little to the overall numbers of sheep over time.

Low levels of bighorn sheep at Kofa NWR stymies managers' ability to augment or re-establish sheep populations, range-wide. Lessening our management options hurts our abilities to assist ailing populations of bighorn sheep, many with populations remaining flat or in decline across the southwest (AGFD unpublished).

Our results do not imply that other factors, such as habitat quality or climate change, are not contributing to the Kofa NWR bighorn sheep population decline. However, these effects would largely act additively in reducing the bighorn sheep population. They are being investigated elsewhere. Analyses herein simply illustrated that predation could be a cause in generating the reported decline in numbers of desert bighorn sheep at Kofa NWR.

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ARTHUR CARHART NATIONAL WILDERNESS TRAINING CENTER

MINIMUM REQUIREMENTS DECISION GUIDE

WORKSHEETS

". . . except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act..."

– the Wilderness Act, 1964

Please refer to the accompanying MRDG instructions for filling out this guide.

The spaces in the worksheets will expand as necessary as you enter your response.

Limiting Mountain Lion Predation on Desert Bighorn Sheep on the Kofa National Wildlife Refuge

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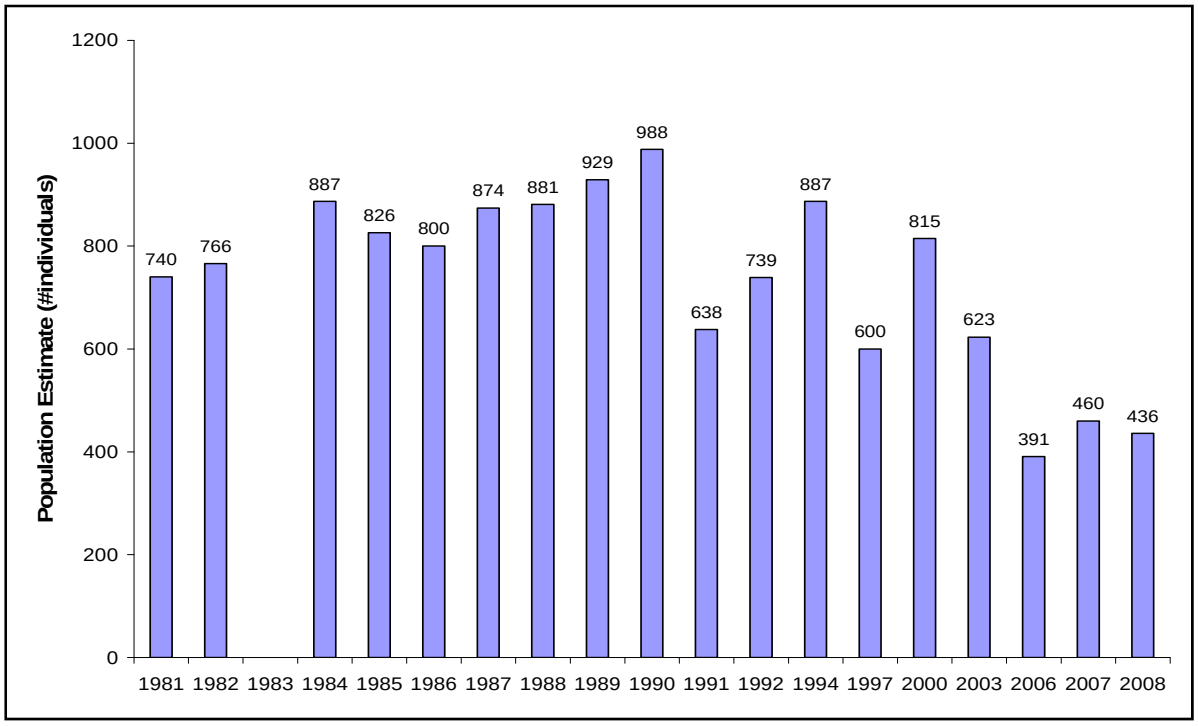
Step 1: Determine if any administrative action is <u>necessary</u>.

Description: Briefly describe the situation that may prompt action.

Recent surveys have shown a significant decline in bighorn sheep (*Ovis canadensis mexicana*) numbers on Kofa National Wildlife Refuge (Refuge). Annual surveys over the past 3 years indicate the sheep population is roughly 50% of the long-term average of 760 (Figure 1). This limits the Refuge's ability to meet wildlife conservation mandates as they relate to desert bighorn sheep. The Refuge is also unable to support landscape level translocation programs for bighorn sheep when the population is at this level. Providing sheep for transplants is an important landscape level goal identified by the Refuge and partner agencies. Maintaining a viable bighorn sheep population is critical to fulfilling the Refuge's purpose and maintaining an important wilderness value.

Figure 1. Kofa NWR Bighorn Sheep Population Estimates, 1981-2008.



To determine if administrative action is <u>necessary</u>, answer the questions listed in A - F on the following pages.

A. Describe Options Outside of Wilderness

Is action necessary within wilderness? **Yes:** ☑ **No:** ☐

Explain:

The Kofa Wilderness is one of the few areas left that is large enough and has the correct habitat configuration to support large numbers of desert bighorn sheep in a single protected area. While there are many mountain ranges in southern Arizona that contain bighorn sheep, these populations are often too small to ensure sustainability or to serve as source populations for broader conservation efforts. Many of these isolated areas are also federally designated wilderness managed by the BLM or FWS.

The significance of the Refuge is that it contains the largest contiguous block of habitat for desert bighorn sheep in southwest Arizona. While site-specific actions can sometimes be effectively conducted outside wilderness, broad scale management actions must occur within wilderness. Wilderness designation covers 510,000 acres of the Refuge's 665,400 acres. In many instances, conservation actions directed at bighorn sheep on the Refuge will need to be conducted within wilderness.

Desert bighorn sheep populations are at risk or declining in many areas throughout their range in the southwest. Intervention to manage adverse impacts brought on by anthropogenic forces is frequently necessary. The impact of natural factors such as drought, disease and predation are exacerbated by unnatural factors such as habitat fragmentation, disease transmission by livestock, and direct disturbance caused by recreation. Historically, natural cyclic population fluctuation, even complete extirpation from specific mountain ranges, posed no serious lasting effect. This was true because bighorn sheep were able to move easily between mountain ranges, and often did, enabling appropriate habitats to be re-colonized and existing herds to receive genetic exchange. Unfortunately, human induced habitat fragmentation has seriously limited the ability of desert bighorns to move between areas of their historic range. Specific barriers in southern Arizona would include the cities of Tucson, Phoenix, other municipalities, the Central Arizona Project, other large canals, agricultural development along the Gila River, Interstate 10, Interstate 8, other highways, and growing recreational pressures. The introduction of disease through contact with livestock can also have dramatic impacts on bighorn herds, sometimes eliminating them in areas altogether. Isolated populations can also be vulnerable to human disturbance as was demonstrated near Tucson's Pusch Ridge, where hikers and their pets had dramatic effects on bighorns. Considering this information collectively, one can begin to understand the need for active management of this species, including the need to conduct transplants of desert bighorn sheep to specific areas as the need arises. For example, suitable habitats currently unoccupied due to a disease event may justify a translocation of several sheep at once, while smaller numbers of sheep may be needed for translocations to maintain genetic viability in smaller populations. The management of desert bighorn sheep populations in the few larger blocks of habitat that remain is critical in order to have lasting source populations.

B. Describe Valid Existing Rights or Special Provisions of Wilderness Legislation

Is action necessary to satisfy valid existing rights or a special provision in wilderness legislation (the Wilderness Act of 1964 or subsequent wilderness laws) that allows consideration of the Section 4(c) prohibited uses? Cite law and section.

Yes: ☐ **No:** ☑ **Not Applicable:** ☐

C. Describe Requirements of Other Legislation

Is action necessary to meet the requirements of other laws?

Yes: ☑ **No:** ☐ **Not Applicable:** ☐

Explain:

The National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C.§668dd, as amended) states, "the mission of the System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." The Act emphasized that the Refuge System was created to conserve wildlife and their habitats. The Act defines conservation as sustaining, restoring or enhancing healthy populations of fish, wildlife, and plants utilizing methods and procedures associated with modern scientific resource programs. The Act directs the Service to manage each refuge to fulfill the mission of the System as well as the specific purposes for which that refuge was established. The specific purpose of Kofa National Wildlife Refuge is found in Executive Order 8039 and is "for the conservation and development of natural wildlife resources." The conservation of desert bighorn sheep was the driving force behind the establishment of the Refuge.

D. Describe Other Guidance

Is action necessary to conform to direction contained in agency policy, unit and wilderness management plans, species recovery plans, or agreements with tribal, state and local governments or other federal agencies?

Yes: ☑ **No:** ☐ **Not Applicable:** ☐

Explain:

The *Kofa National Wildlife Refuge & Wilderness and New Water Mountains Wilderness Interagency Management Plan and Environmental Assessment* (USDI 1997) does not address predator management. However, it does address the significance of the bighorn sheep population on the Refuge and its importance in helping to achieve Refuge purposes, including its value as a wilderness resource and source population for regional translocations. The plan states that the Service will maintain and enhance the natural diversity of flora and fauna within the planning area and this will be done within a dominant wilderness context. The plan goes on to state that the Service will manage wilderness portions of the planning area using the minimum tools needed for maintaining an optimal desert bighorn sheep population while providing for maximum viable species diversity.

E. Wilderness Character

Is action necessary to preserve one or more of the qualities of wilderness character including: untrammeled, undeveloped, natural, outstanding opportunities for solitude or a primitive and unconfined type of recreation, or unique components that reflect the character of this wilderness area?

Untrammeled:	**Yes:**	☐	**No:**	☑	**Not Applicable:**	☐
Undeveloped:	**Yes:**	☐	**No:**	☑	**Not Applicable:**	☐
Natural:	**Yes:**	☑	**No:**	☐	**Not Applicable:**	☐

Explain: The presence of desert bighorn sheep in the wilderness is important, and they represent an important aspect of the naturalness of this specific wilderness area. The appropriate stewardship of this wilderness resource is required to fulfill the purposes of the Refuge, including the Wilderness Act.

Outstanding opportunities for solitude or a primitive and unconfined type of recreation:

Yes: ☐ **No:** ☑ **Not Applicable:** ☐

Other unique components that reflect the character of this wilderness:

Yes: ☐ **No:** ☑ **Not Applicable:** ☐

F. Describe Effects to the Public Purposes of Wilderness

Is action necessary to support one or more of the public purposes for wilderness (as stated in Section 4(b) of the Wilderness Act) of recreation, scenic, scientific, education, conservation, and historical use?

Recreation:	**Yes:**	☐	**No:**	☐	**Not Applicable:**	☑
Scenic:	**Yes:**	☐	**No:**	☐	**Not Applicable:**	☑
Scientific:	**Yes:**	☐	**No:**	☐	**Not Applicable:**	☑
Education:	**Yes:**	☐	**No:**	☐	**Not Applicable:**	☑
Conservation:	**Yes:**	☑	**No:**	☐	**Not Applicable:**	☐

Explain: As described earlier in the document, the conservation of desert bighorn sheep at the Refuge is necessary for broader scale management and restoration of this important wildlife resource. The Kofa bighorn herd is one of very few populations able to support transplant programs for landscape level conservation of this species.

Historical use:	**Yes:**	☐	**No:**	☐	**Not Applicable:**	☑

Step 1 Decision: **Is any administrative action necessary in wilderness?**

Yes: ☑ **No:** ☐ **More information needed:** ☐

Explain:

The Refuge was established in 1939 by Executive Order 8039 which described the legal purpose being "for the conservation and development of natural wildlife resources, and for the protection of public grazing lands and natural forage resources." The Refuge is managed to fulfill the mission and goals of the Refuge System, as well as the specific purpose for which the Refuge was established. The conservation of desert bighorn sheep was the driving factor in the establishment of the Refuge. The presence of a thriving bighorn sheep population is an important indication that the Refuge is fulfilling its purpose.

With the passage of the Arizona Desert Wilderness Act of 1990, about 510,000 acres of the Refuge's 665,400 acres became designated wilderness. For wilderness areas within the Refuge System, the purposes of the Wilderness Act are considered to be "within and supplemental" to the purposes for the specific Refuge. Put another way, the wilderness

purposes are additional purposes and must be harmonized with specific Refuge purposes as well as the mission of the Refuge System.

In response to the noted decline of bighorn numbers on the Refuge, the Service and the Arizona Game and Fish Department (AGFD) prepared a report in April 2007 titled: *Investigative Report and Recommendations for the Kofa Bighorn Sheep Herd* (Investigative Report). The purpose of the report was to provide an analysis of the probable causes of the decline and a strategic approach to a management program intended to lead to the recovery of this important wildlife resource. The plan includes three sections. Part 1 describes the current problem and provides some historical context. The heart of the plan is Part 2, where issues are identified, and strategies to manage them are recommended. Part 3 is a concise matrix that contains prioritized implementation strategies. Many of the proposed management strategies are currently being implemented and include annual surveys to assess population dynamics, monitoring mortality factors such as disease and predation, and managing water availability. The need to manage predation was also recommended in the report. However, additional analyses, such as this "minimum requirements analysis" were needed prior to implementing that particular action.

The specific action being considered is to provide the Service additional options for the management of the Refuge's sheep population by allowing the Service to limit predation by mountain lions. This would include the removal of "offending" lions by either lethal means or through translocation. An "offending mountain lion" is defined as one that has killed two or more desert bighorn sheep within a six-month period.

As stated earlier, the Refuge contains the largest contiguous block of habitat for desert bighorn sheep in southwest Arizona. The regional importance of this sheep population is widely recognized and has been a source for translocations since 1957. In fact, over the years 569 bighorn sheep have been captured on the Refuge and released in new areas to supplement populations in Arizona, New Mexico, Colorado, and Texas. The Refuge bighorn sheep have provided vital population boosts and genetic variety to bighorn sheep herds throughout the southwest.

The Refuge's role in the landscape level management of desert bighorn sheep cannot be overstated. Very few areas are able to provide sheep for translocations. The Refuge must meet the population objectives for sheep in order to carry out these conservation actions. Implementing the management actions outlined earlier in the document are needed to help meet both Refuge purposes and population objectives tied to the transplant program. This includes limiting mountain lion predation on bighorn sheep.

Maintaining an optimal desert bighorn sheep population requires a multi-faceted approach. Predation management as one of the tools is appropriate under certain circumstances, and guidance for such activity is found in several policies. For example, the Refuge Wilderness Policy (610 FW 2.20) allows actions that alter natural predator-prey relationships when they help achieve our purposes and compelling evidence exists that the proposed action will correct or alleviate identified impacts on native fish, wildlife, plants, or their habitats and the control is directed at the individual animal(s) causing the problem. The Service's wilderness policy also

states that we will maintain or restore the biological integrity, diversity, and environmental health of the wilderness area.

Setting population objectives for one species, seemingly at the expense of another species, warrants further discussion as it relates to Service policies. The Service's Biological Integrity, Diversity, and Environmental Health policy (601 FWS 3) states that each refuge will be managed to fulfill the refuge purpose as well as the Refuge System mission, and we will accomplish this by ensuring that the biological integrity, diversity, and environmental health of the refuge is maintained. Biological integrity, diversity, and environmental health can be described at various landscape scales from refuge to ecosystem, national, and international. Each landscape scale has a measure of these factors dependent on how the existing habitats, ecosystem processes, and wildlife populations have been altered in comparison to historic conditions. Individual refuges can contribute to biological integrity, diversity, and environmental health at larger landscape scales, especially when they support populations and habitats that have been lost at a larger scale. In pursuit of refuge purposes, individual refuges may at times compromise elements of biological integrity, diversity, and environmental health at the refuge scale in support of those components at a larger landscape scale. When evaluating the appropriate management direction for refuges, the Service considers the refuge's contribution to biological integrity, diversity, and environmental health at multiple landscape scales.

The bighorn sheep population objectives set for the Refuge are an example where management direction was developed in support of landscape level conservation efforts. This is particularly true with regard to objectives meant to support transplant programs across a multi-state area. Service policy states that we manage populations for natural densities and levels of variation, however, on some refuges, including those with purposes tied to particular species, we can establish goals and objectives to maintain densities higher than those that would naturally occur in order to support conservation at multiple scales. Service policy also promotes, when and where practical, the support of reintroduction programs for native species in the context of surrounding landscapes.

In addition, removing mountain lions to reduce predation of bighorn sheep is intended to reduce the number of lions on the refuge, not eliminate them entirely. In a larger context, mountain lions have expanded their North American range eastward in recent years and occupy mountain ranges throughout the state of Arizona. Reducing mountain lion numbers on the refuge would have little to no impact on statewide or nationwide populations.

While actively managing predation in wilderness introduces a form of human supervision, this manipulation is in response to larger scale human disruption of landscape level ecosystems. There is a trade-off of trammeling one aspect of wilderness character locally to enhance or restore another wilderness resource for broader purposes. The predator-prey processes will be trammeled as a result of the action, but other wilderness values related to bighorn sheep will be enhanced.

Again, natural processes are difficult to describe in this case. The anthropogenic forces described earlier have had larger impacts. Specific management actions directed at bighorn sheep in wilderness may not be meant to increase or maintain the "naturalness" of the wilderness at a specific location or for a specific process. Rather, they may be intended to allow the

numbers of desert bighorn sheep on the Refuge to increase for broader purposes. Prior to significant alteration of the region by humans, desert bighorn sheep would have been able to move between mountain ranges and cross desert floodplains and re-colonize mountain ranges where sheep numbers may have dropped for a variety of reasons, including predation or disease. Movements of sheep are now greatly restricted by highways, fences, canals, and human habitation.

In conclusion, there is a need to provide conservation actions in wilderness for desert bighorn sheep on the Refuge. The specific administrative action of limiting predation is needed in order to enhance the bighorn sheep population. This will further Refuge purposes, including Wilderness Act purposes, and help meet the Refuge System mission.

If action is <u>necessary</u>, proceed to Step 2 to determine the <u>minimum</u> activity.

Step 2: Determine the minimum activity.

Description of Alternatives

For each alternative, describe what methods and techniques will be used, when the activity will take place, where the activity will take place, what mitigation measures are necessary, and the general effects to the wilderness resource and character.

Alternative No. 1 – Limiting Mountain Lion Predation on Desert Bighorn Sheep on the Refuge (Proposed Action)

Description:

The proposed action includes capturing mountain lions, fitting them with tracking devices, and releasing them in order to follow their movements and document what prey they kill. This allows Service biologists to gather the necessary data to determine "offending lion status." The EA defines an "offending lion" as one that, subsequent to its release, kills two or more bighorn sheep in a six month period. Under certain circumstances, lions fitting those criteria would be subject to removal. Lions removed would either be killed humanely, or relocated, if appropriate areas or organizations are found to receive the lion(s).

The primary circumstances that would guide lion removal actions are bighorn sheep population estimates. When the bighorn sheep population on the Refuge is estimated to fall below 600 animals, those mountain lions found to kill two or more sheep within a six-month period could be removed from the refuge. If the bighorn sheep population is estimated to be 800 animals or greater, the capturing, collaring, and monitoring of mountain lions could continue, but no lions would be removed. When the bighorn sheep population is estimated to be between 600 and 800 animals, multiple factors would be used to consider the totality of the circumstances before lions are removed. Lamb survival and recruitment, bighorn sheep population trend, and environmental conditions would be considered. The behavior of individual lions would be taken

into account as well. For example, lions may be allowed to kill up to four desert bighorn sheep within a six-month period before removal. Long-term monitoring of mountain lion populations through use of remote cameras, scat surveys, scent stations and subsequent tracking of captured lions with satellite GPS or radio collars is proposed to continue at all estimated desert bighorn sheep population levels.

The equipment used to capture mountain lions would include pan tension devices and break-away snares. The trap sites may be baited or unbaited and optimal trap sites may be located by individuals on horseback with the assistance of lion-tracking hounds. Scent stations would typically consist of a 1-meter square area of fine dust centered on scent bait used to attract predators. Aerial darting of mountain lions, cage trapping where the box cages are placed by helicopter and the use of hounds may also take place. All handling of lions, including sedation, would be done according to established protocols.

When the lions kill a prey item, the sites are investigated by a biologist. Typically, this would be accomplished by hiking to the site. Only rarely, and in the case of a very remote kill site, would the visit be accomplished by using a helicopter. The information gathered at the kill site is time sensitive and requires a quick response by the biologist in order to obtain the most possible data.

Effects:

Wilderness Character

"Untrammeled"

The proposed action affects wilderness character, in so far as it alters natural predator-prey relationships. Service policy states that predation is an essential and integral process in the wilderness ecosystem and that we will initiate actions intended to alter these processes only when compelling evidence exists that the proposed action will correct or alleviate identified impacts on native wildlife, plants, or habitats (610 FW 2.20). Service policy also states that we will not interfere with these processes or the wilderness ecosystem's response to such natural events unless necessary to accomplish refuge purposes, including Wilderness Act purposes, or in case where these processes become unnatural (610 FW 2.16). Discussion in the associated EA points out anthropogenic influences such as habitat fragmentation, climate change, recreation, artificial waters, and others may currently be impacting bighorn sheep numbers within the Refuge and that the multi-faceted management program being implemented, including predation management, is needed to address the issue. Service policy also states that predation management in wilderness will be directed at the individual animal(s) causing the problem. These actions must support the conservation of wildlife and their habitats in wilderness in a manner consistent with the National Wildlife Refuge System Improvement Act of 1997 and Refuge purposes, including Wilderness Act purposes. The proposed action is part of the broader approach intended to conserve desert bighorn sheep consistent with applicable statutes and Refuge purposes. The proposed action targets only the individual mountain lions preying on sheep and is not intended to eliminate mountain lions from the ecosystem. Mountain

lions are expected to remain part of the ecosystem and contribute to wilderness character and play an important ecological role.

"Undeveloped"

There would be temporary visual intrusion in the wilderness from equipment and materials, including small cameras and materials placed at trap sites. However, the discreet nature of trap placement reduces the chance that the public will encounter these devices and so this activity is not expected to significantly detract from the visiting public's experience. Scent stations may constitute a new visual intrusion but the effect would be temporary and affect only a very small area. All of these activities are expected to occur in short duration at each location and permanent impacts to the sites will be negligible or non-existent. No more than 18 trap sites are expected to be managed on the Refuge at any one time during any trapping effort, making encounters with the public extremely unlikely. All vehicles would remain on the Refuge's designated roads. The imprint of man's work would remain substantially unnoticeable and the Refuge would continue to contrast with other areas of growing mechanization.

"Outstanding opportunities for solitude or a primitive and unconfined type of recreation"

The use of helicopters would be a temporary visual and auditory intrusion in wilderness. Should a member of the public encounter a trap site or witness the use of a helicopter, it may adversely affect their wilderness experience. Conversely, the expected increase in the number of desert bighorn sheep and the increased possibility of viewing sheep may improve the wilderness experience of the visiting public. Visitors are unlikely to be able to view mountain lions under any of the Alternatives due to the lions' secretive nature and nocturnal habits.

Outstanding opportunities for solitude or a primitive and unconfined type of recreation offered on the Refuge would continue in the proposed action.

"Natural"

The removal of mountain lions found to regularly prey on desert bighorn sheep is expected to allow the numbers of desert bighorn sheep on the Refuge to increase. Before human influence in the region, desert bighorn sheep would have been able to move between mountain ranges and cross desert floodplains and re-colonize mountain ranges where sheep numbers may have dropped for a variety of reasons, including predation or disease. Movements of sheep are now greatly restricted by highways, fences, canals, and human habitation.

In contrast, mountain lions are able to move great distances at night and have been found to cross highways and other barriers and travel near and through areas of human habitation. Mountain lions have apparently re-colonized the Refuge after a long period (from 1944 until 2001) when mountain lions were not detected. AGFD estimates that there are between 2,500 and 3,000 mountain lions in Arizona. The ability of mountain lions to produce several kittens in one litter and to cross manmade barriers gives lions greater reproductive potential compared to desert bighorn sheep. The removal of lions known to regularly prey on desert bighorn sheep

would allow the numbers of desert bighorn sheep to increase while allowing mountain lion movements and reproduction to continue.

Other unique components that reflect the character of this wilderness

The Refuge wilderness is characterized by rugged desert mountain ranges surrounded by bajadas and separated by vast desert flats. There is evidence of past hard rock mining, livestock grazing, and the work of the Arizona Conservation Corps in the form of old roads, small concrete dams, mines, tailings piles, cemeteries, historic buildings, wells, windmills, and a corral in and immediately adjacent to wilderness. There is also past evidence of the work of the Service in the form of spring improvements and small shades and other structures in and near wildlife water sources. The Refuge is known since its inception for its conservation of desert bighorn sheep and its habitat. These unique components would not be altered or affected in the proposed action.

Heritage and Cultural Resources

In the proposed action, traps, cameras, scent stations would not be placed where they would impact Refuge cultural or historic resources. Prior to their placement, the area would be checked for cultural resources including rock art, lithic scatters, and pot shards, and those resources would be avoided.

Maintaining Traditional Skills

The proposed action includes a long-term effort to trap and release mountain lions. Trapping of animals is a traditional skill that requires intimate knowledge of animal behavior and great care in the cryptic placement of traps. Hiking cross-country to place cameras, scent stations, and traps or to reach kill sites could be considered a traditional skill. Locating and evaluating evidence at the kill sites (including drag marks, dried blood, caches, scrapes, and carcass remains) can also be considered a traditional skill. The use of horses for transportation and hounds trained to track mountain lions is an additional traditional skill.

Special Provisions

The special provisions of wilderness designation which allow mining activity to continue on unpatented mining claims that were present at the time of the passage of the Desert Wilderness Act of 1990 would not be changed by the implementation of Alternative 1 – Proposed Action. The maintainance of wildlife water sources considered critical for bighorn sheep using mechanized tools covered in the Refuge's existing planning (USDI 1997) would continue.

Economic and Time Constraints

The proposed action requires a multi-year financial commitment by the Service, as trapping, tracking, and removing lions will require significant funding. Arrangements and agreements are in place with partner organizations to share the cost of implementing this alternative. It is anticipated that funding will be provided through the Service and partners.

The urgency of the action is driven by the depressed numbers of sheep on the Refuge and the cessation of regional translocation programs. Also, recent rainfall patterns on the Refuge have been favorable (at or above average since 2004) and have resulted in vegetation and habitat conditions beneficial for most wildlife, including bighorn sheep. The removal of "offending mountain lions" during this period may provide an exceptional opportunity to bolster desert bighorn sheep numbers on the Refuge.

Additional Wilderness-specific Comparison Criteria

The Refuge is at the center of the largest contiguous piece of desert bighorn sheep habitat for the subspecies *mexicana* (*Ovis canadensis mexicana*). While other mountain ranges contain this subspecies, they generally do not have a population of desert bighorn sheep large enough to support transplants of sheep from those mountain ranges to other mountain ranges where desert bighorn sheep numbers have declined or have been extirpated. The Refuge has been a source population for sheep transplants within Arizona and in the surrounding states for over 50 years. Transplants have been suspended since 2006, when the Refuge sheep population was found to have dropped to approximately 390 animals. Other mountain ranges in Arizona have been found to be able to support the removal of a few animals at a time, but cannot support the removal of 25 to 30 animals at one time, which is the desired number of bighorn sheep to effectively re-colonize a new area. The San Andres NWR in New Mexico, and the Bighorn, Santa Catalina, and Mineral Mountains in Arizona are examples of areas where proposed desert bighorn sheep transplants are on hold pending an increase in sheep numbers on the Refuge. Alternative 1 – the Proposed Action supports the restoration of sheep numbers to allow sheep transplants to resume.

Safety of Visitors, Personnel, and Contractors

Individuals operating power tools would need safety glasses, hearing protection and gloves for initial placement of cameras/monitoring equipment. Subsequent monitoring efforts would continue to require appropriate outdoor work attire (large-brimmed hat, sunscreen, etc) and preparation. Individuals responsible for handling and administering drugs to mountain lions and potentially relocating mountain lions would receive appropriate training and certification. Those individuals riding or working near helicopters or participating in any airborne capture attempts would require additional training and personal protective equipment.

Alternative No. 2 – No Action

Description:

Under the No Action Alternative, the Refuge would continue to be managed as it has been in the past. The Service would not limit mountain lion predation on desert bighorn sheep on the Refuge under this alternative. This is considered the environmental baseline, or *status quo*. Since bighorn sheep management and mountain lion predation management outside the Refuge have been conducted in Arizona for decades, the environmental baseline can be

considered as including the effects of the current ongoing programs. The wildlife population baselines are those that are in place under the current condition of the human environment which means they incorporate and reflect the populations as they have been and are being affected by humans.

The Service currently has no plan to guide the management of mountain lions. Current management efforts, described in the Refuge's management plan (USDI 1997), focus on the maintenance of critical wildlife water sources for bighorn sheep, and, in coordination with the AGFD, monitor desert bighorn sheep numbers, set the number of hunt permits, and consider transplants to augment populations elsewhere in the region. Research on wildlife and wildlife water sources would continue. Collection of mountain lion scat for composition analysis and the collaring of mountain lions and desert bighorn sheep would continue. The study of desert bighorn sheep health and causes of mortality on the Refuge would continue.

Effects:

Wilderness Character

"Untrammeled"

The No Action Alternative could be considered more consistent with wilderness values than the proposed action from the standpoint that natural processes would be allowed to occur since there would be no direct alteration of the predator-prey relationship within the wilderness area. However, the predator-prey relationship of mountain lions and desert bighorn sheep on the Refuge may be influenced by AGFD efforts to limit mountain lion predation on desert bighorn sheep outside of the Refuge.

"Undeveloped"

The effect of Alternative 2 – No Action would be similar to that of Alternative 1 – Proposed Action, except that no intrusions from trapping sites would be present. There would still be limited intrusions from camera monitoring and other research activities

"Outstanding opportunities for solitude or a primitive and unconfined type of recreation"

The use of helicopters for wildlife surveys and other administrative activities described in the Refuge's existing planning (including USDI 1997) would be a temporary visual and auditory intrusion in wilderness. Should a member of the public witness the use of a helicopter, it may adversely affect their wilderness experience. Outstanding opportunities for solitude or a primitive and unconfined type of recreation offered on the Refuge would continue under Alternative 2 – No Action.

"Natural"

As pointed out earlier, the naturalness of the Refuge is somewhat compromised by prior and ongoing anthropogenic forces, and has become increasingly difficult to evaluate. Bighorn sheep

are an important component of wilderness and if mountain lion predation is not managed or limited, bighorn sheep numbers may decline. While it is unlikely that the bighorn sheep herd would be completely extirpated, it could drop to levels that require much more intensive, invasive management procedures to prevent extirpation. These activities could also impact wilderness values in the long term.

Other unique components that reflect the character of this wilderness

The effect of Alternative 2 – No Action is the same as Alternative 1 – Proposed Action.

Heritage and Cultural Resources

The effect of Alternative 2 – No Action is the same as Alternative 1 – Proposed Action.

Maintaining Traditional Skills

The effect of Alternative 2 – No Action would be similar to that of Alternative 1 – Proposed Action. Traditional skills used for trapping, including uses of hounds and horses, would not be maintained, although the use of skills necessary for cross-country hiking and investigation of kill sites of collared sheep would continue.

Special Provisions

The effect of Alternative 2 – No Action is the same as Alternative 1 – Proposed Action.

Economic and Time Constraints

Continued efforts to monitor desert bighorn sheep and mountain lions through collaring efforts, scat analysis, and remote camera monitoring carry a financial cost that is similar to Alternative 1. However, future conservation actions to manage bighorn sheep on the Refuge may be more intrusive and costly if numbers continue to fall.

Additional Wilderness-specific Comparison Criteria

Under Alternative 2 – No Action, the desert bighorn sheep population on the Refuge would not expected to increase to the point where sheep transplants can resume. The priority placed on desert bighorn sheep conservation on the Refuge would end, and transplants to mountain ranges where sheep numbers have declined or disappeared entirely would not take place.

Safety of Visitors, Personnel, and Contractors

The effect of Alternative 2 – No Action is the same as Alternative 1 – Proposed Action.

Alternative No. 3 – Indiscriminate Removal of Mountain Lions

Description:

Under this alternative, there would be no attempts to distinguish "offending lions." Lions would be lethally removed or captured and relocated out of the Kofa Mountains Complex (Kofa, New Water, South Plomosa, Tank, Little Horn, and Castle Dome Mountains). Efforts would be made to remove approximately two mountain lions per year from the area until the sheep population reached approximately 800 animals and exhibited an increasing trend based on at least 3 sheep population surveys. Lion removals would resume if the desert bighorn sheep population was found to again go below 800 animals. Lethal removal and translocation techniques would be identical to those in Alternative 1. Research and monitoring of wildlife would continue as earlier described. Under this alternative, the indiscriminate removal of mountain lions may not necessarily remove those animals known to regularly kill desert bighorn sheep.

Effects:

Wilderness Character

"Untrammeled"

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action. The indiscriminate removal of mountain lions may allow the numbers of desert bighorn sheep to increase, but it may also include the removal of animals that are not regularly consuming desert bighorn sheep. Because of this, Alternative 3 may not meet Service policy under 610 FW 2.20.

"Undeveloped"

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

"Outstanding opportunities for solitude or a primitive and unconfined type of recreation"

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

"Natural"

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Other unique components that reflect the character of this wilderness

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Heritage and Cultural Resources

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Maintaining Traditional Skills

The effect of Alternative 3 No Action is the same as Alternative 1 – Proposed Action except that the traditional skill of evaluating wildlife sign and evidence would not take place since the mountain lions would not be collared and released on the Refuge. There would be no regular opportunity to evaluate mountain lion kill sites since finding these locations without following the movements of a radio-collared mountain lion are very rare. The exception would be when a radio-collared bighorn sheep is found dead and the carcass examined.

Special Provisions

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Economic and Time Constraints

This would be the least costly and least time consuming alternative, since no effort would be made to monitor the activities of mountain lions before they are removed. This alternative might also avoid more costly, invasive efforts to preserve sheep populations that might be required under Alternative 2.

Additional Wilderness-specific Comparison Criteria

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Safety of Visitors, Personnel, and Contractors

The effect of Alternative 3 is the same as Alternative 1 – Proposed Action.

Comparison of Alternatives

It may be useful to compare each alternative's positive and negative effects to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character."

	Alternative 1 Proposed Action	Alternative 2 No Action	Alternative 3
Untrammeled	-	+	-
Undeveloped	-	+	-
Natural	+	-	+
Solitude or Primitive Recreation	-	+	-
Unique components	+	-	+
WILDERNESS CHARACTER	++/---	+++/--	++/---

When considering wilderness character, Alternative 2 is the most beneficial.

	Alternative 1 Proposed Action	Alternative 2 No Action	Alternative 3
Heritage & Cultural Resources	NA	NA	NA
Maintaining Traditional Skills	+	+	-
Special Provisions	NA	NA	NA
Economics & Time	-	-	+
Additional Wilderness Criteria	+	-	+
OTHER CRITERIA SUMMARY	++/-	+/--	++/-

When considering other criteria, Alternatives 1 and 3 are the most and equally beneficial.

	Alternative 1 Proposed Action	Alternative 2 No Action	Alternative 3
SAFETY	NA	NA	NA

Safety Criterion

If safety issues override impacts to wilderness character or other criteria, provide documentation that the use of motorized equipment or other prohibited uses is necessary because to do otherwise would cause increased risks to workers or visitors that cannot be satisfactorily mitigated through training, use of personal protective equipment (PPE), or other requirements to alleviate the safety risk. (This documentation can take the form of agency accident-rate data tracking occurrences and severity; a project-specific job hazard analysis; research literature; or other specific agency guidelines.)

Documentation:

Safety issues do not override impacts to wilderness character or other criteria in this analysis.

Step 2 Decision: What is the Minimum Activity?

Selected alternative:

Alternative 1 – Proposed Action

Rationale for selecting this alternative:

Alternative 1 - the Proposed Action is selected because it supports the effort to meet the bighorn sheep population goals described in the existing Refuge planning documents and supports the transplant goals for desert bighorn sheep within Arizona and in other parts of the southwest. Alternative 1 is in compliance with Service policy (610 FW 2.20) since the proposed predation management in wilderness would be directed at the individual animal(s) causing the problem. Alternative 1 is also in compliance with Service policy (610 FW 2.16) since the Service has determined that the interference with ecosystem processes (in this case, predator/prey relationships) and the ecosystem's response to this natural event is necessary to accomplish refuge purposes, including Wilderness Act purposes. Alternative 1 supports the conservation of wildlife and their habitats in wilderness in a manner consistent with the National Wildlife Refuge System Improvement Act of 1997. The proposed action targets only the individual mountain lions preying on sheep and is not intended to eliminate mountain lions from the ecosystem. Mountain lions are expected to remain part of the ecosystem and contribute to wilderness character and play an important ecological role.

Alternative 1 would be implemented by qualified Service employees or their agents upon completion of the associated Environmental Assessment / Management Plan and issuance of a FONSI.

Monitoring and reporting requirements:

The effectiveness of the Proposed Action would be accomplished through regular aerial surveys of the desert bighorn sheep populations. Populations of mountain lions would continue to be monitored using cameras, scent stations, and radio-collaring. The health of the desert bighorn sheep would continue to be monitored using radio-collars and health checks including, but not limited to, laboratory analysis of blood samples collected at the time of radio-collaring.

The location for trap sites and other activities associated with the action will be determined through ongoing monitoring efforts. This monitoring is accomplished with temporarily-installed remote cameras and scent stations in order to obtain more information about the number and movements of mountain lions on the Refuge. We will periodically attempt to capture and radio-collar mountain lions using snares, box traps, or pan-tensioning devices, which would be set and removed after each mountain lion capture effort. We would follow the movements of the mountain lions using the GPS locations obtained remotely from the collars, and investigate those locations where a lion kill is likely to have taken place. We would remove mountain lions found to kill two or more desert bighorn sheep in a six-month period. All equipment and tools would be carried on foot by and all equipment and materials would be removed after completion of each phase of the project. Helicopters may be used to check remote locations where collared mountain lions have made a kill. All vehicles would remain on designated roads outside of wilderness. Any cameras, snares, box traps, scent stations, or other equipment would be located using GPS so no permanent marking would be required. Any disturbance would be temporary and localized.

All equipment used would be packed in and out on foot or horseback or with the use of helicopters and would be removed at the conclusion of each phase of the work. All individuals involved would employ Leave No Trace techniques throughout the project. All vehicles would remain on designated roads outside of the wilderness. If horses and hounds are used, all water and feed required by horses and hounds during lion capture must be brought in and use of pelletized feed and feed containers will be encouraged.

Check any Wilderness Act Section 4(c) uses approved in this alternative:

- ☐ mechanical transport
- ☐ motorized equipment
- ☐ Motor vehicles
- ☐ motorboats
- ☑ landing of aircraft
- ☐ temporary road
- ☐ structure or installation